GEORGIA

State Board of Entomology

BULLETIN No. 1—April, 1899.

I. Legislation Against Crop Pests.

II. Dangerous Pests Prescribed by the Board, with Remedial Suggestions.

BY

W. M. SCOTT.

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Georgia State Board of Entomology.

O. B. STEVENS, Chairman, Commissioner of Agriculture, Atlanta.

P. J. BERCKMANS, Pres. of State Horticultural Society, Augusta.

J. POPE BROWN......Pres. of State Agricultural Society, Hawkinsville.

W. M. SCOTT, M. S., Entomologist and Sec. of the Board, Atlanta.

To the Honorable Board of Entomology of the State of Georgia:

Sirs—I have the honor to submit the accompanying manuscript for publication and distribution in accordance with an Act of the General Assembly, approved December 20, 1898.

The first part is offered in answer to the many inquiries received at this office, concerning the requirements of the recently enacted crop pest law; and to place this law and the regulations enacted by the Board in the hands of interested persons in convenient form. Part second is meant to briefly call to attention the insects and diseases designated by the Board as dangerously injurious to plants, with suggestions for remedial work.

Very respectfully,

W. M. SCOTT,
State Entomologist.

Approved:
O. B. Stevens, Chairman of the Board.

I. Legislation Against Crop Pests.

In December of the year 1897 an Act was passed by the General Assembly of Georgia providing for a special Department of Horticulture and Pomology to be added to the Department of Agriculture, with one officer who should be an Entomologist. The Entomologist was appointed March 1, 1898, and nearly the whole of his time during the year was spent in the field with the fruit growers, nurserymen and truckers. The result of his work is given in the report to the Commissioner of Agr.culture, which was published in the Annual of the Department of Agriculture for 1898.

This law proved defective in some particulars, and at the recent session of the Legislature it was amended.

The full text of the amended law and the rules and regulations enacted by the Board of Entomology acting thereunder are given below:

An Act to amend an Act entitled: "An Act to require the Commissioner of Agriculture to establish a special department of Horticulture and Pomology, to employ an Entomologist, fix his salary and define his duties, to provide for inspection of fruit trees, fruit, vineyard, melon and vegetable farms, and prevent, diminish and destroy contagious diseases and destructive insects in orchards, vineyards and other places; to provide boards of arbitration, fix their powers, define their duties and provide for their costs; to provide funds for the maintenance of said department, to prescribe penalties for violations, and for other purposes." Approved December 21, 1897.

Approved December 20, 1898.

Be it enacted by the General Assembly of Georgia:

1. That an Act entitled "An Act to require the Commissioner of Agriculture to establish a special department of Horticulture and Pomology, to employ an Entomologist, etc., etc., approved December 21, 1897, be amended so as to read as follows:

Section 1. That from and after the passage of this Act, the Commissioner of Agriculture of the State of Georgia, the President of the Georgia State Horticultural Society and the President of the Georgia State Agricultural Society shall, ex-officio, constitute a Board to be known as the State Board of Entomclogy, of which the Commissioner of Agriculture shall be chairman, which Board shall

have full power to enact such rules and regulations governing the inspection, certification, sale, transportation and introduction of trees, shrubs, cuttings, buds, vines, bulbs and roots, that they may deem necessary to prevent the further introduction, increase and dissemination of insect pests and plant diseases.

Section 2. That the State Entomologist appointed by the Commissioner of Agriculture under the provisions of the Act cited above, approved December 21, 1897, shall act as an inspector under the provisions of this Act, and it shall be the duty of the said Board to promulgate rules and regulations in accordance with this Act for the government of the said Entomologist in the duties devolving upon him in the execution of the provisions of this Act.

Section 3. That the salary of the said Entomologist shall not exceed $1,500.00 per annum, and that said salary shall be paid out of the funds in the Agricultural Department arising from the inspection of oils. In addition to the above appropriation the sum of $1,000.00 per annum is hereby appropriated out of the funds in the Agricultural Department arising from the inspection of oils, for the purpose of defraying the expenses of the execution o this Act,—the equipment of a laboratory, the traveling and other incidental expenses of the Entomologist and the issuing of reports and other publications.

Section 4. The Entomologist shall have power under the regulations of the Board of Control, to visit any section of the State where such pests are supposed to exist, and shall determine whether any infested trees or plants are worthy of remedial treatment or shall be destroyed. And he shall immediately report his findings in writing, giving reasons therefor, to the owner of the infested plantation, his agents or tenants, and a copy of each report shall also be submitted to the said Board. In case of objection to the findings of the Inspector, an appeal shall be made to the said Board, who shall have the power to summon witnesses and hear testimony on oath. and whose decision shall be final. An appeal must be taken within three days and shall act as a stay of proceedings until it is heard and decided.

Section 5. Upon the findings of the Inspector in any case of infested trees or plants, the treatment prescribed by him shall be executed at once (unless an appeal is taken), under his supervision; cost of material and labor shall be borne by the owner; PROVIDED, HOWEVER, that in case the trees or plants shall be condemned, they shall be destroyed by the Inspector, and the expense of such action shall be borne by the owner. No compensation shall be allowed for any plants that shall be destroyed.

Section 6. In case any person or persons refuse to execute the directions of the Inspector or of the said Board after an appeal, the County Judge, or Ordinary shall, upon complaint filed by the Inspector or any freeholder, cite the person or persons to appear before him within three days notice after being served, and that the said

Judge or Ordinary may hear and determine all these cases in vacation; and, upon satisfactory evidence, shall cause the prescribed treatment to be executed, and the expense thereof and costs of court shall be collected from the owner or owners of infested plants.

Section 7. It shall be unlawful to offer for sale, sell, give away or transport plants, scions, buds, trees, shrubs, vines or other plants, tubers, roots, cuttings, bulbs, known to be infested with dangerously injurious insects or plant diseases. Any person or persons violating this section shall upon conviction thereto be guilty of a misdemeanor.

Section 8. The said Board of Control, its agents or employees, are hereby empowered with authority to enter upon any premise in discharge of the duties herein prescribed. Any person or persons who shall obstruct or hinder them or their agents in the discharge of these duties shall be deemed guilty of a misdemeanor, and, upon conviction thereof, shall be guilty of a misdemeanor.

Section 9. The Board shall have the power to also adopt rules and regulations, not inconsistent with the laws and Constitution of this State and the United States, for preventing the introdution of dangerously injurious crop pests from without the State, and for the governing of common carriers in transporting plants liable to harbor such pests to and from the State, and such regulations shall have the force of laws.

Section 10. It shall be unlawful for any grower, nurseryman or corporation to ship within the State of Georgia any trees, shrubs, cuttings, vines, bulbs, roots without having been previously inspected by either a State or Experimental Station Entomologist or government officer, within twelve months of the date of said shipment, and certificate of inspection to accompany each box or package. Violation of this clause will be considered as a misdemeanor and punishable as such.

Section 11. Be it further enacted that the members of the said Board, any two of whom shall constitute a quorum in the absence of the third, shall, within 30 days from the passage of this act, draw up and promulgate through the press of the State the rules and regulations necessary to carry into full and complete effect the provisions of this Act, carefully defining what diseases or maladies, both insect and fungus, shall constitute infestation in trees or plants within the meaning and purview hereof.

Section 12. Be it further enacted, that any person or persons residing in the State of Georgia, dealing in or handling trees, etc., shall be compelled to have his or their stock inspected annually on or before the 1st of November each year. If, upon such inspection, such stock is found to conform to the requirements of the Board of Control, the Inspector shall furnish a certificate to that effect. And any such person or persons making a shipment before the filing of such certificate with the chairman of the Board of Control shall be guilty of a misdemeanor.

Section 13. Each and every person residing in States or Coun-

tries outside of the State of Georgia, dealing in or handling trees, plants, cuttings, vines, shrubs, bulbs and roots in this State, shall register his name or firm and file a copy of his or its certificate of inspection furnished by the Entomologist, Fruit Inspector or duly authorized government official of his State or Country, with the Chairman of the Board of Control. Upon failure so to do, said stock shall be liable to confiscation under order of the Inspector.

Section 14. When two reputable citizens of any county in Georgia shall notify the Board, from belief, that noxious insects or plant diseases exist in their county, the said Inspector shall be directed to ascertain as speedily as possible by personal investigation, and in such other manner as he may deem expedient, the extent of the infection, and shall act with all due diligence to suppress and eradicate the said pests and give notice to the owner, tenant or agent of such premises to treat such infested plants according to the methods he may prescribe, or destroy them within ten days from date of such notice, and if after the expiration of such period of ten days the infested plants have not been treated or the treatment has not been properly applied or is not effectual in ridding plants of the pests, the Inspector shall cause such plants to be properly treated or destroyed as his judgment warrants. The cost of the work shall be covered by execution from the owner of the premises.

Section 15. It shall be the duty of the Inspector to make a monthly report of his work, both as Entomologist and Inspector, to the Board of Control, as well as the expenditure under this Act, and said Board shall report annually to the Governor of the State.

2. This act shall take effect from and after its passage, and all laws and parts of laws in conflict with this Act are hereby repealed.

On January 18, 1899, the Board of Entomology met in Macon, Ga., with all of its members present and adopted the following rules and regulations:

Rules and Regulations for the Government of the State Entomologist in the Enforcement of the Act of the General Assembly of Georgia, Providing for the Control and Eradication of the Insect Pests and Fungous Diseases which Threaten the Fruit and other Agricultural Interests of the State, and for the Prevention of the Further Introduction of Dangerously Injurious Crop Pests from Without the State.

Adopted January 18, 1899.

In pursuance of an Act of the General Assembly of the State of Georgia, approved December 20, 1898, amendatory to an Act of Assembly approved December 21, 1897, creating a Board of Entomology, and authorizing and directing the

same to take action for the suppression of certain hereinafter defined injurious insects and fungous diseases, and for the prevention of the further introduction, increase and dissemination of the same; the following rules and regulations are hereby enacted and promulgated:

1. In accordance with Section 11 of said Act, the following insects, fungous diseases and parasitic plants are hereby declared, individually and severally, to constitute infestation in trees and plants; this list to be revised at the will of the Board of Entomology:

(1) The San Jose scale *(Aspidiotus perniciosus)*
(2) The New Peach scale *(Diaspis amygdali)*.
(3) The Cabbage Web-Worm *(Hellula undalis)*.
(4) Black Knot *(Plowrightia morbosa)*.
(5) Peach Yellows.
(6) Peach and Plum rosette.
(7) Mistletoe *(Phoradendron flavescens)*—parasite.

2. The State Entomologist is hereby charged with the enforcement of the said act, and as inspector is directed to locate by personal investigation, correspondence and in such other manner as he may deem best, the above named pests so far as they exist in this State, and give proper directions and take such steps in accordance with the above cited act as he may deem necessary to control or eradicate the same.

3. In accordance with Section 5 of the above cited act, the State Entomologist is hereby endued with power to condemn and destroy any infested trees, shrubs or other plants that in his judgment are not worthy of remedial treatment, when such infestation is, or is likely to become a menace to the agricultural interests of any section of the State, or when the owner or owners of infested premises shall refuse or neglect to properly execute the treatment prescribed for him.

4. Any trees, shrubs or other plants commonly known as nursery stock, shipped within the State of Georgia, without each box, bundle or package in each car load, or less than car load lot being plainly labeled with an official Entomologist's certificate to the effect that the contents of the same have been inspected and found to meet with the requirements of the Board of Entomology in accordance with Section 10 of the act cited above, shall be liable to confiscation upon the order of the inspector.

5. Each and every box, bundle or package of trees, shrubs and other plants commonly known as nursery stock, shipped in car load lots, or less than car load lots into the State of Georgia from any other State or country, shall be plainly labeled with a certificate of inspection furnished by the Ento-

mologist, Fruit Inspector or other duly authorized official in the State or country in which said stock was grown, and also with the official tag of the Georgia State Board of Entomology hereinafter provided for; said certificate and tag to be valid for only twelve months from the date they bear, in accordance with Sections 9 and 13 of the act cited above. Such shipments not so labeled shall be liable to confiscation upon the order of the inspector.

6. Upon the filing of the proper certificate as above prescribed in accordance with Section 13 of said act, and upon request of any person or persons residing in states or countries outside of the State of Georgia, dealing in or handling trees, shrubs or other plants in this State, the certificate of the said Board of Entomology will be issued to the same without charge, and official tags bearing a *fac simile* copy of such certificate and the seal of the State Board, will be furnished such applicants at cost, viz: Sixty cents for the first 100 or part thereof, and twenty-five cents for each additional hundred.

7. No transportation company or common carrier shall deliver any box, bundle or package of trees, shrubs or other plants commonly known as nursery stock, shipped from any other state or country to any consignee at any station in the State of Georgia, unless each box, bundle or package is plainly labeled with a certificate of inspection furnished by the official Entomologist of the state or country in which said stock was grown, and also with the official tag of the Georgia State Board of Entomology hereinabove provided for. Such shipments of the nature designated above originating in the State of Georgia, need only have the certificate of the State Entomologist; and unless his certificate is attached to each and every box, bundle or package of trees, etc., they shall not be accepted for transportation.

8. Transportation companies shall immediately notify the State Entomologist (Atlanta, Ga.) when by oversight, negligence or otherwise, any shipment of uncertified stock is received at any station or wharf in the State, and it shall be his duty to proceed as speedily as possible to investigate and dispose of such stock, as provided for in the act cited above.

9. The State Entomologist shall have power to require any nurseryman of the State to fumigate his stock with hydrocyanic acid gas, when in his judgment the presence of any pest in the nursery or in the neighborhood of the nursery, warrants such treatment for the better protection of the agricultural interests of the State. Upon the failure of any individual, firm or corporation to comply with this requirement,

the State Entomologist is hereby authorized to withhold his certificate from the same.

10. The State Entomologist is hereby authorized to publish in the form of bulletins, reports, or through the press of the State any matter pertaining to the distribution, life history, habits and treatment of insect pests and fungous diseases, or other matter that may be instructive or aid in the suppression of such pests.

11. The Board of Entomology may appoint temporary deputy inspectors when it appears to be necessary, to assist the Entomologist in the enforcement of the act cited above, and such deputy inspectors shall have full power to enter on premises and inspect and report to the State Entomologist.

12. Appeals from the decision of the Entomologist should be addressed to the Commissioner of Agriculture, Atlanta, Ga., who shall notify the appellant of the time and place of hearing such appeal.

13. The State Entomologist shall be secretary of the Board, and all inquiries relative to the provisions of the above cited act and the subject matter of the same should be addressed to him at Capitol Building, Atlanta, Ga.

This amendatory act creates a State Board of Entomology, making the Department of Entomology a distinct department of its own operated under the directions of the Board. It is much easier of execution than the original law and affords protection to the individual who wishes to keep his premises clear of pests against a careless or obstinate neighbor whose premises may be infested. It is only necessary for two reputable citizens of any county in Georgia to notify the Board that noxious insects or plant diseases exist in their county, as provided for in section 14 of the act, and it becomes the duty of the Entomologist to immediately cause the affected plants to be properly treated or destroyed, as his judgment warrants.

The writer wishes to urge that infested communities take the matter in hand in an organized effort to stamp out the infestation. Cases of infested or diseased premises should be reported to the Entomologist, and the organized community should see that his directions are properly carried out. The Board maintains that it would be impossible for the Entomologist to personally superintend the treatment of individual cases in a state as large as Georgia, where the interests involved are so great, and only one man to look after it all. He can only make the inspections and report his findings with the proper recommendations. If it is afterwards determined, however, that the treatment recommended has not been properly ap-

plied, then it becomes his duty to cause such diseased premises to be properly treated and to subject the offender to punishment, as prescribed by law.

One of the most important features of the law is the regulation of the transportation of plants which are undoubtedly the most effectual medium of wide dissemination of insects and fungous diseases. Nurserymen are required to have their premises inspected and secure the Entomologist's certificate before they are allowed to ship their stock. Nurserymen outside of the State doing business in the State are required to secure the certificate of the Entomologist of the State or country in which their stock is grown, and file the same with the Board of Entomology; and upon this certificate, if it be satisfactory, the Board issues to them official tags bearing its certificate, which must be used in the shipment of stock into the State.

Transportation companies are prohibited from delivering transported plants unaccompanied by the proper certificate. The transportation companies of the State have kindly expressed to the Board their intention to co-operate with it in the enforcement of the law.

It is not the purpose of the law to interfere in the least with the traffic of plants nor to prevent honest nurserymen from doing business in this State, but rather to insure such plants from dangerous pests and to protect the industry.

Under the existing law, it is proposed to pursue the following lines of work:

1. To continue the nursery inspection work, destroying all stock found actually infested with dangerous pests, and requiring fumigation whenever deemed necessary, thereby preventing the further dissemination of such pests from sources in this State.

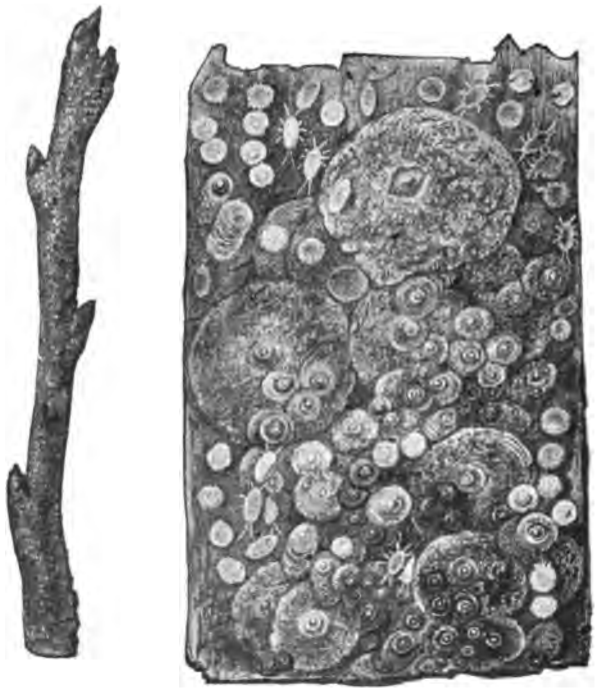
2. To rigidly enforce the regulations governing nurserymen outside of the State in the shipment of stock to this State, thereby preventing the further introduction of dangerous pests so far as possible.

3. To continue the inspection and treatment of infested and diseased premises, endeavoring to suppress the pests that have already gained a foothold.

4. To conduct experiments with insecticides and fungicides, determining the most practical and effective methods of combatting insect pests and diseases of plants.

II. Dangerous Pests Prescribed by the Board, With Remedial Suggestions.

(1) THE SAN JOSE SCALE *(Aspidiotus perniciosus* Comstock.)



a b

FIG. 1. Appearance of scale on bark: *a*, infested twig, natural size; *b*, bark as it appears under hand lens, showing scales in various stages of development, and young larvae. (Howard and Marlatt, Bul. No. 3, New Series, Div. of Entomology, U. S. Dept. of Agr.)

How to detect it.—This scale is very small and it is rather difficult for an inexperienced eye to detect it. Roughly speaking, it is about the size of a pinhead. Seen under a hand lens the female is dark gray in color, circular and conical in outline, and terminates at the center by a nipple like prominence,

surrounded by a distinct ring. The male scales are elongated and smaller, with the nipple near the anterior end. The real insect beneath the scaly covering is plump, circular in outline and yellowish. If crushed with the point of a knife the result is a pale yellowish liquid. The newly born young are very minute mite-like creatures, long oval in shape, with pale orange color. They are quite active in seeking a suitable spot on which to settle, and in a few hours they have anchored themselves with their beak for life; except in the case of the males, which issue at maturity with wings, and become active again.

When a tree becomes crusted over with these scales the bark has the grayish appearance of having been coated over with dampened ashes.

Food Plants.—The San José scale may be looked for upon the following plants: Peach, plum, apple, pear, apricot, cherry, quince, almonds, rose, Hawthorn, raspberry, spiraea, cotoneaster, prunus pissardii, strawberry, flowering quince, mountain ash, gooseberry, currant, flowering currant, grape, English walnut, pecan, black walnut, persimmon, elm, osage orange, linden, euonymus, weeping willow, Kilmornock willow, English willow, golden willow, cotton-wood, Lombardy poplar, Carolina poplar, catalpa, sumach, silver maple and perhaps some others.

In Georgia it has been found on the peach, plum, apple, pear, prunus pissardii, rose, Kilmornock Willow, cotton-wood, Carolina Poplar and a few others.

Present status.—This scale is now known to exist in about thirty counties of the State, and some of the most important fruit sections are involved. The work of combatting it, however, has been very vigorous and it has been greatly reduced in the last twelve months. Many trees have been dug up and remedies have been freely used. Nurseries have been thoroughly inspected and infested ones cleaned up. The fumigation of nursery stock is now being generally adopted by the nurserymen and every precaution is being taken to prevent the further spread of this dreaded pest.

Treatment.—For nursery stock, fumigation with hydrocyanic acid gas in an air-tight room is the only safe remedy; and, in fact, this treatment cannot be considered an absolute surety against the scale, since some unknown opening in the house may allow the gas to escape before it has done its deadly work. Where trees are actually known to be infested they should never be used, but should be burned. There is too great a risk in the use of infested stock, no matter to what treatment it may have been subjected. Fumigation is a good precaution and every nurseryman should fumigate his stock,

not only on account of the probable existence of scale in his nursery, but also on account of other insects that are usually present on nursery trees to a greater or less extent. This work of fumigation is accomplished by packing the trees in an *airtight* room and subjecting them to the fumes of hydrocyanic acid for thirty-five minutes. The gas is generated by treating chemically pure potassium cyanide with the best grade of commercial sulphuric acid at the rate of 1¼ oz. of cyanide, 1¾ oz. of acid and 5 oz. of water to every 150 feet of cubic space in the room.

Among the several remedies now known to be effective in orchard work, the kerosene treatment is the most useful with us. Many orchards in South Georgia have been treated with the mechanical mixtures of kerosene and water during the past winter and most excellent results have been obtained. Twenty and twenty-five per cents of oil are the strengths we have most commonly used for winter treatment. Our experiments have shown that it is not safe to use over twenty-five per cent., and even then considerable injury wil result if the weather conditions are not just right. It is absolutely necessary that bright dry days should be selected for this work, otherwise serious injury to the trees may be expected. If the atmosphere is not sufficiently dry to allow the oil to evaporate quickly, it will penetrate the bark and cause injury. The writer wishes to press the importance of this caution, because a number of trees were killed the past winter from neglect of it. At least two applications of the twenty or twenty-five per cent. mixture should be made during the dormant period. The first as soon as the foliage is shed in the fall and the second in the spring before the buds begin to open. For summer treatment, fifteen per cent kerosene is as strong as we dare to use with safety. This should be applied at any time during the summer when living scales are detected.

Special Kero-water sprayers are necessary to effect this treatment. These machines are so constructed that the desired percentage of kerosene can be regulated quite accurately. The Deming Company, Salem, Ohio, have had these pumps on the market for some time, and the Gould Manufacturing Company, Seneca Falls, N. Y., have just recently put out an excellent "Kero-water" sprayer.

The gas treatment of orchard trees by means of tents has produced satisfactory results wherever properly used. On account of its expensiveness, however, only a few growers are using it in this State. Whale-oil soap, two pounds to the gallon of water, thoroughly mopped or sprayed on the trees in the dormant season is also a good remedy. One application is not sufficient to effectively check the scale. The treatment should be repeated two or three times during the season.

Freezing out.—It will be of interest to mention the effect that the February freeze had on the San José scale; and, in fact, it has its bearing on the treatment of this insect. On February 28, fifteen days after the freeze, I commenced to investigate the condition of the scale in Southwest Georgia. Infested orchards were examined in nearly every section of the State where the scale exists. Making a rough estimate, I would say that at least ninety per cent. of the insects were killed in every orchard examined. Where the kero-water mixture had been used on the trees very few living scales could be found and in many cases none at all. It seems that the insects that had escaped the treatment had been so weakened by it that they were less able to resist the cold.

This freezing out of the scales at a temperature of four to eight degrees below zero, which was not expected, since the same insect withstands the greater cold of the more northern latitudes, can be accounted for by the fact that they had been awakened from their winter hibernation by the warm days that preceded the freeze. Caught in this semi-active condition, they had to succumb to the cold. Moreover, insects as well as plants in Southern latitudes are not as thoroughly protected and do not become as dormant as in the North.

The forbes scale *(Aspidiotus forbesi)*, a closely allied species to the San José scale, however, seems not to have been effected by the cold.

The reproductive power of the San José scale is so enormous, illustrated by the fact that the female produces four or five young a day for a period of about six weeks after reaching maturity, that the ten per cent. that escaped the freeze is sufficient to soon thoroughly reinfest the orchards. This small per cent., however, should be easily controlled if the proper steps are taken during this summer. Infested trees should be sprayed with ten or fifteen per cent. of kerosene in the early part of the summer, followed in the fall with an application of the twenty or twenty-five per cent.

(2) THE NEW PEACH SCALE.

(Diaspis amygdali Tryon.)

FIG. 2. The New Peach Scale: *a* branch covered with male and female scales, natural size; *b*, female scale; *c*, male scale; *d*, group of male scales—enlarged. (Howard, U. S. Dept. of Agr., Yearbook, 1894.)

How to detect it.—This scale is readily distinguished from the San José in that the female is a little larger, of a lighter gray color, with the elongated exuvial point ridged and located at one side of the center, and the male is smaller, elongated, with parallel sides and white. The exuvial point is similar to that of the female, but located at the anterior end. A tree badly infested has a white-washed appearance from the color of the male scales. Where only females occur, however, a grayish brown appearance is produced.

It is the habit of these insects to cluster about the trunk and the lower parts of the larger limbs of a tree.

The original home of this insect is probably either the West Indies or Japan. From its probable West Indian origin it gets one of its popular names, "West India" scale. It is now known to exist in the United States, at Washington, D. C.; at Los Angeles, Cal.; in one locality in Ohio; at Molino, Fla.; at Bainbridge, Thomasville, Irby and Ashburn, Georgia. The case at Irby, Ga., involves two peach orchards; one of about 7,000 trees and the other 25,000 trees. About 10,000 trees have been utterly destroyed at this place by this scale.

It attacks the peach, plum, apricot, cherry, pear, grape, persimmon, and a few other plants.

Treatment.—The winter treatment for this insect is about the same as that for the San José scale. The females pass the

winter in the mature and partially mature state, and can be killed by the twenty per cent. mixture of kerosene and water, or by the whale-oil soap treatment at the rate of one pound dissolved in one gallon of water. In Georgia there are three or four broods from eggs, which appear at more or less regular intervals, the first appearing about the midde of March, if the season is favorable. These broods should be watched for and ten per cent. kerosene or whale-oil soap at the rate of one pound to four gallons of water should be applied at the time of their appearance.

It is becoming one of the most dangerous pests with which we have to contend, perhaps equal to the San José scale. The most vigorous measures should be adopted for its eradication while it is yet in its incipiency.

Fortunately this scale was also almost completely frozen out by the February freeze.

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(3) THE CABBAGE WEB-WORM.

(***Hellula undalis*** Fab.—***Botis rogatalis*** Hulst.)*

Under date of August 15, 1898, Mr. Geo. Maul, of Augusta, Ga., informed the writer that in August of 1897 a new enemy to the cabbage and other plants of the mustard family appeared in his and neighboring truck gardens in the form of a small caterpillar. He stated that this same insect had appeared again at the date of his letter, declaring that it was quite impossible to grow cabbages and turnips around Augusta on account of it, and urged this department to come to their rescue. Upon request, Mr. Maul sent the writer alcohol specimens of the caterpillars and as the species could not be identified they were forwarded to Dr. L. O. Howard, Entomologist of the United States Department of Agriculture. Dr. Howard replied that it was indeed a new enemy to the mustard family and could not be identified from the larvae. Living specimens of the caterpillars were secured from which were bred several moths and forwarded, together with living larvae, to Dr. Howard. These were identified by comparison with specimens in the National Museum, by Messrs. Dyar and Chittenden, as ***Hellula undalis*** Fab., an introduced species which has been recorded from Texas.

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* As this Bulletin goes to press, the writer receives Bulletin No. 19, New Series, U. S. Department of Agriculture, Division of Entomology, which contains an account of ***Hellula undalis***, by Mr. F. H. Chittenden, similar in some particulars to the matter in this paper.

In a letter concerning this insect, dated November 16, Dr. Howard Writes: "There is some doubt about the Texas locality, and it is quite probable that the occurrence at Augusta, Ga., is the first of this species in this country. * * * It is obviously a species of the greatest economic importance, as the chances are that it will spread northward and soon take rank among our most pernicious cruciferous pests, of which we already have a superfluity."

About the middle of October, 1898, the writer made an investigation of the ravages of this pest around Augusta, visiting six or eight truck farms. The turnips, cabbages, radishes and other cruciferous vegetables grow off nicely for about ten days after they come up, but within another week they are swept away by this little worm. Acres and acres are thus devastated. Some truckers planted the same piece of ground over five times with the same result—the loss of the whole crop each time. Mr. Maul planted eight pounds of cabbage seed in frames and carefully stretched mosquito-netting over them, hoping thereby to exclude the moths and secure a crop of cabbage plants. In spite of this precaution, the moths gained entrance and the crop was lost. Some truckers have estimated their losses up in the thousands of dollars, but it is difficult to make a fair estimate of the damage done in Richmond county.

Excepting the infestation in Richmond county, about Augusta, no other locality in the State is known to be infested. It is reported that the cabbage and turnip crops about Waycross, Ga., were almost a complete failure last fall, due to some insect trouble, possibly the cabbage webworm. This is not certain, however, since no investigation has been made.

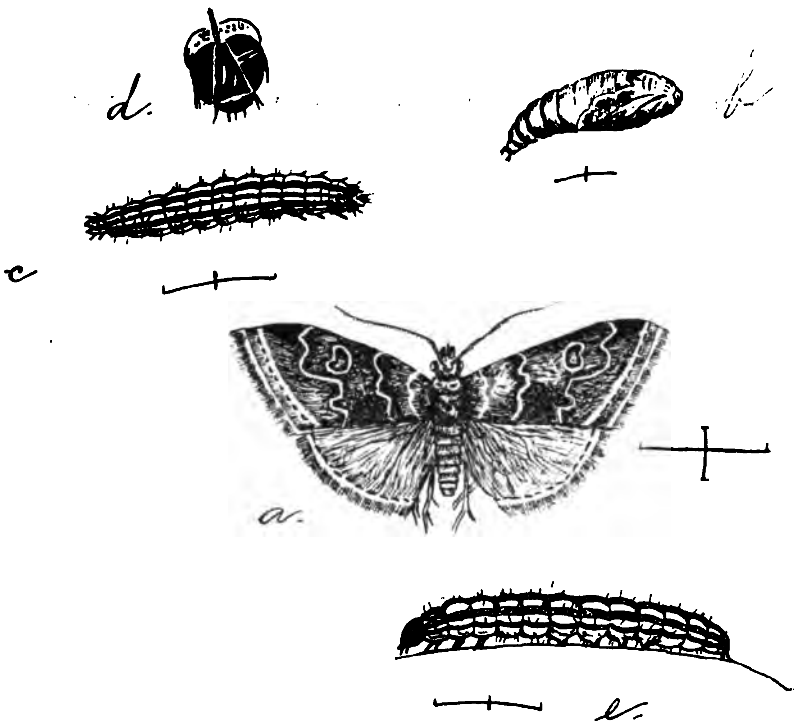

FIG 3. *Hellula undalis*: *a*, moth; *b*, pupa; *c* and *e*, larva, dorsal and lateral view; *d*, head of larva—all much enlarged. (Original.)

DESCRIPTION OF THE DIFFERENT STAGES.

The egg.—The egg is about .8 mm. in diameter, nearly spherical, slightly oblong with a sharp teat-like projection at one end and light yellow in color. The shell is thin and membranous, filled with a yellowish fluid. The embryo develops very rapidly, and a few hours before the larva issues the egg takes on a pinkish brown color, until finally, with the aid of a hand lens, the characteristic black head of the caterpillar can be seen.

The Larva.—In length the full grown worm measures about five-eighths of an inch (16 mm.); nearly cylindrical, with greatest diameter about 2.7 mm., near the midddle, tapering toward each extremity. In color it is a dull pinkish cream, with seven brownish purple stripes traversing the entire length of the body, excepting the head and first thoracic segment, one on the dorsimeson and three on each side; the third or lower

lateral one is usually somewhat indistinct. Also, a ventrimeson stripe and on each side a latero-ventral stripe of the same color can be readily distinguished in the young larva; these fade away and almost disappear as the worm approaches maturity and the general color becomes lighter. The body bears a few hairs which can scarcely be seen without the aid of a lens. The three pairs of true legs and the five pairs of pro-legs are quite well developed.

The head is horny and polish-black, as illustrated in figure 3, *d*. The first thoracic segment is furnished with a black shield which is very conspicuous in the young larva, but fades off into a light brown color, with broken longitudinal, dark brown bars as maturity is approached.

The Pupa.—The pupa, shown much enlarged at *b*, in the figure, is full five-sixteenths of an inch (8.2 mm.) long; the head and the portion showing the outlines of the wings are dark fuscous, and the other portion of a lighter yellow color. The anal segment terminates with four hairs. The dark brown eyes and general outline of the moth can be quite plainly distinguished.

The Adult.—The moth is figured at *a*, much enlarged, in the accompanying illustration. The female moth is described under the name, ***Botis rogatalis*** by Dr. Hulst, in the Transactions of the American Entomological Society, Vol. XIII., page 149, as follows:

Expands 19 mm. Palpi, head, thorax and abdomen fuscous; fore wings broken fuscous and fuscous cinereous; the basal space with a black spot medially, two white lines cross the wings, the first extra basal edged with dark fuscous, outer after the typical ***Botis*** pattern; a dark brown spot annulated with white at reniform; a dark brown subtriangular apical patch, and a subterminal white line; marginal line black, broken; hind wings, even fuscous; beneath, lighter, lines obsolete, reniform indistinct.*

HABITS AND LIFE HISTORY.

The observations made on the habits and life history of this insect were conducted both in the field and in the laboratory. It should be stated, however, that on account of frequent interruptions, caused by the necessity of carrying on the fall nursery inspection work at the same time, its life history could only be worked out incompletely. One of the most important phases, the number of broods, was not determined.

It is the purpose of the writer to make a more complete

* This technical description was copied from Dr. Hulst's paper and furnished the writer through the courtesy of Dr. Howard.

study of its life history the present season and conduct a series of experiments with insecticides for its destruction, and publish the results.

As stated before, this insect was first observed at Augusta in Richmond county about the middle of August, 1897. It was probably introduced a year or two earlier but did not occur in sufficient numbers to attract attention. According to Dr. Howard (communicated by letter to the writer, under date of November 28), its original home is probably Southern Europe.

Its destructive work in the fall of 1897 attracted considerable attention among the truckers of Richmond county, but it was not expected that it would prove such a pernicious pest. In the first days of August of the following season it appeared in such vast numbers, sweeping every vestige of cruciferous plants before it, that the gardeners became alarmed. Protective and remedial measures of different kinds were tried; mosquito netting was used over beds of cabbage plants, arsenical poisons were used on field crops, but all of no avail.

The caterpillars are first noticed in about ten days or two weeks after the plants have come up. As many as twenty may be found on one plant. They eat out the bud or heart of the young plant and stop its growth at once. Then they gnaw the leaf stems and even the stalk and cut them so nearly off that they break down. Roots are not attacked except in the case of turnips, where the worms occasionally gnaw into the top of the turnip roots.

Cabbages, turnips, radishes and collards are devoured with equal relish. Other plants of the family *cruciferae* also undoubtedly furnish food for this insect. No other plants are known to be attacked.

Fig. 4. A turnip plant with the bud eaten out by *Hellula undalis*.

The moth deposits her eggs singly on the lower surface of the leaves. These are scattered promiscuously, as indicated at *e*, in figure 4. Twenty to thirty eggs were observed to be deposited by each of several females in the breeding cages. It is quite probable that even more are usually deposited. The eggs are hatched in two to three days after deposition. Eggs deposited on the under side of turnip leaves in the breeding cages, on the 5th of November, were hatched on the 8th of November. Others deposited on the 6th were hatched on the 9th. The little caterpillars are very active and immediately upon issuing they descend directly into the bud of the plant, where they begin their destructive work. After feeding for a few hours they begin to spin threads of silk from leaf to leaf and from one margin of a leaf to the other. The small leaves are often partially rolled with the worms inside, by means of these threads. More often, however, they spin little web-bags against the leaves or leaf stems near where they

are feeding, into which they hastily retreat when disturbed. In case they are feeding on turnip plants, where they feed near the ground the bag is free, touching the ground and is coated over with little grains of sand which cling to the silk threads.

According to observations made in the laboratory, the larvae take from twenty to twenty-five days to develop from the eggs to the pupa stage. Worms that issued on November 9th pupated from the 1st to the 7th of December.

After reaching full growth they resort to some convenient place on the stem or leaf of the plant, or burrow beneath the sand, usually the latter, and spin a small cocoon in which the transformation takes place. They may remain in the cocoon for two or three days before the pupa is completely formed. About ten or twelve days are consumed in the pupa stage. In the breeding cages larvae that pupated from the 22d to the 25th of October emerged as moths on December 1st to 5th. Others that pupated December 7th emerged December 18th.

Copulation takes place in a few hours after the moths emerge from the pupa state. The eggs develop very rapidly and are deposited in a few hours after impregnation takes place. The moths begin to fly in the evening after sunset, depositing their eggs on the lower surface of the leaves. They remain hidden during the day, usually on the under surface of leaves and under rubbish on the ground, with their wings folded in the position shown in figure 4. When disturbed they fly off a few yards and suddenly dart down into a hiding place. They fly low and in somewhat of a darting motion. They were never found to be feeding, and the indications are that they live and do their work in the few days of their existence without feeding, although this point was not definitely determined. Those that were bred in the cages where there was no food for them copulated and laid their eggs normally, which would indicate that there was at least no necessity for food. As stated before, the number of broods was not determined; but since less than six weeks are required for the insect to complete its life cycle, and since the first brood appears in the early days of August and the last one reaches to the 1st of December, we can reasonably conclude that there are at least three broods. It is highly probable, too, that there is a July brood, which may not occur in sufficient numbers to attract attention. Cold weather usually catches the last brood and cuts its work short. On November 29th, after a few frosts had appeared, the writer visited a truck farm near Augusta and found the caterpillars greatly reduced in numbers and very sluggish. Very little damage was done by them after November 15th.

How they pass the winter was not determined, but as an opinion it is suggested that they very likely hibernate as pupae.

Parasites.—From the material brought into the laboratory was reared an Ichneumonid, which is presumably a parasite on this webworm. Dr. Howard writes that two distinct species of parasites were bred from the material sent to his office.* Definite information concerning the natural enemies of this insect cannot yet be given. It is quite probable, however, that this most dangerous cruciferous pest will be greatly held in check by its parasites.

Treatment.—Sufficient experiments have not yet been made to authorize the recommendation of any definite course of treatment for this particular insect. The habit the worms have of darting back into their protecting web when disturbed precludes the use of contact poisons. Internal poisoning can undoubtedly be effected with more or less success. The most efficacious remedy that suggests itself then, perhaps, is Paris green, either suspended in water or used as a dry powder. If used in water, four or five ounces of the poison to fifty gallons of water is the proper proportion. The mixture should be well agitated and applied with a fine spray nozzle. Several applications will be necessary to effect good results, the first to be made as soon as the first pair of true leaves of the plant has come out (if the insect has appeared on the premises), the second in about a week after the first, and others at intervals of ten days, as may seem necessary. It, perhaps, would not be well to use the poison within a week of the time the vegetables are to be marketed. If the poison is to be used as a powder it should be thoroughly mixed with gypsum or flour at the rate of one part of the poison to twenty parts of the diluent and dusted on the plant.

Some of the truckers of Richmond county used arsenical poisons last year with apparently no effect; yet we believe that if they are thoroughly applied and used often enough destruction of a large per cent. of the worms will result. The usual caution against the danger of carelessly handling arsenic should be observed.

The moths are readily attracted by lights. On October 17, after nightfall, the writer took a lantern out into an infested turnip field and in two minutes a dozen or more moths were flying around the light, which would suggest that they could

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* On page 56, Bul. No. 19, (N. S.), U. S. Department of Agriculture, Division of Entomology, Mr. F. H. Chittenden gives the names of these parasites as the Tachina fly, *Exorista piste*, Walk, and the Ichneumonid, *Limneria tibiator* Cr.

be readily captured by trap-lanterns. Lanterns arranged over pans of Kerosene oil and placed at intervals of say forty yards over the garden would doubtless trap a large number of moths before they lay their eggs.

In the fall or during the winter all trash, as weeds, old cabbage stalks and other *debris* in and around fields that were infested the previous season should be raked up and burned and the overwintering brood will thereby be reduced.

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(4) BLACK KNOT.

(Plowrightia morbosa Sch.) Sacc.

Fig. 5. Black Knot.—Old knots on cherry twigs, natural size. (Original.)

Plums and cherries are subject to the attacks of a disease very expressively termed "Black Knot." This disease is American in its origin and occurs more or less abundantly throughout the United States, but is especially prevalent in the Eastern States, where it seems to have first appeared. In some sections of the East growers of plums and cherries have been forced from time to time to abandon the industry in consequence of the ruinous effects of its work. Cases are on record showing that orchards that paid handsomely one year were completely destroyed the following year or two. Cherries are little grown in Georgia, but plum culture has become quite an extensive industry, and profitable returns are realized from the marketed fruit.

Realizing the seriousness of this Black Knot fungus, the State Board of Entomology very wisely placed it in the category of dangerously injurious pests and thereby brought it within the purview of the law. While this disease is not very prevalent over the State and a general epidemic has never occurred, yet it was deemed necessary to include it in the list and take steps to hold it under control.

It has been found in quite a good many orchards in the State, but not to any alarming extent. The more intelligent growers are fully aware of the injuries they are liable to suffer from its attacks, and whenever it appears on their premises they lose no time in removing it by cutting off affected parts or rooting up the diseased trees. Through such wise measures the disease has not been allowed to get beyond control.

How to detect it.—Some fully formed knots are illustrated in figure 5. These are large, rough, black excresences, due to the growth of a fungus *(Plowrightia morbosa)* in the cambium layer of the branches or twigs. These crusty enlargements may extend entirely around the branch or grow lengthwise on one side. The first swelling usually begins in the spring, when the sap begins to flow; it may, however, occasionally be noticed in the fall. The first indication is a slight enlargement, usually longitudinal, which rapidly increases in size as the season advances. The bark is soon ruptured and finally scaled off, exposing a yellowish brown crusty surface. In May the fungus bears a crop of infecting spores on the surface of the knot, which gives it a velvety appearance. These spores are soon scattered by the wind or other natural agencies furnishing infection for other trees and thus disseminating the disease. The knot then becomes hard and black as fall is approached. It has not yet completed its work. During mid-winter another crop of spores is produced and scattered. These gain lodgment in the cracks and crevices of the bark and in the forks of twigs and at the growing points,

ready to germinate and penetrate the tissues of the bark as spring opens up.

Treatment.—The most effective method of controlling this disease is to cut out all the knots as soon as they appear and burn them. This work should be supplemented by spraying with Bordeaux (four pounds of copper sulphate and five pounds of fresh lime to fifty gallons of water). Four applications are necessary, two for the winter crop of spores and two for the summer crop. The first should be made about two weeks before the buds begin to open, and the second immediately before they open. The third application should be made about the middle of May at the time the summer crop of spores is produced, followed in about two weeks with the fourth.

All wild cherry and plum trees should be carefully watched, as they are frequently badly attacked, and affected parts must be cut away and burned.

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(5) PEACH YELLOWS.

FIG. 6. Yellows the fourth year. (Smith, Bul. 17, Div. veg. Path., U. S. Dept. Agr.)

This disease has not yet made its appearance in Georgia, but we have every reason to anticipate its introduction at any time, unless diseased stock is effectively excluded from the State. The probability of its introduction and the fact that it carries destruction with it have prompted the Board to place it on the black list that every precaution may be taken to keep it beyond the bounds of the State.

It is American in its origin and has been known for about one hundred years. It is quite generally distributed over the Eastern States north of Tennessee and North Carolina. Some of the most important peach sections of the East have suffered immensely from its destructive work and in not a few cases entire orchards have been completely destroyed. It seems to prefer peaches, but apricots, almonds, nectarines and Japanese plums are not free from its attacks.

How to detect it.—If the affected tree is in bearing, the first symptom is manifested in the premature ripening of the fruit, which may take place several weeks or only a few days before the normal season of ripening. Premature ripening may be due to other causes, but the yellows peaches bear characteristic bright-red, measly blotches over the skin and streaks of red through the flesh, often reaching to the pit. Another reliable symptom is the pushing out of newly formed buds at the ends of apparently healthy twigs or water sprouts, into short shoots with small yellowish leaves. Such buds should not normally put out until the following season. Also, the disease may cause dormant buds on the trunk and larger limbs to push into feeble, often branched shoots, characterized by narrow stiff leaves. This stage is illustrated in figure 6, showing the abnormal growth on a tree dying with the yellows. Affected trees may live for three to five years, during which time they are gradually weakened and finally the foliage becomes yellowish or reddish in color.

The term "yellows" is somewhat misleading. Quite a number of supposed cases of yellows in this State have been reported to the writer, but upon investigation the yellowing of the foliage in every case proved to be due to the peach borers, drouth or some other weakening effect on the trees. Premature ripening of the fruit from similar causes has also lead many to believe their trees to be affected with the yellows. The absence of red spots on the skin and red streaks through the flesh of the fruit should serve to relieve uneasiness in such cases.

The cause of yellows is yet undetermined, but it is definitely known that it is a disease and can be communicated from tree to tree and from orchard to orchard. Experiments have shown that it can be communicated to healthy trees through buds taken from diseased trees, but the manner

of its natural spread from tree to tree is yet unknown. It is known, however, that from scattered cases in the orchard it will gradually spread over the entire orchard and completely destroy it if left unmolested.

Prevention.—Since yellows is an incurable disease, we can only look to preventive measures for protection.

(1) Peach trees should not be obtained from nurseries located immediately in infested sections. Such stock is liable to develop yellows after planting out.

(2) Peach pits from affected trees should never be planted. They may reasonably be expected to convey the disease to th young stocks.

(3) Whenever the disease appears in an orchard every affected tree should be rooted up and burned. Simply cutting off affected parts is not sufficient. The virus exists in the apparently healthy parts and would soon develop the symptoms of yellows. The whole tree, root and branch, must be destroyed.

(6) PEACH AND PLUM ROSETTE.

FIG. 7. Rosette induced in a seedling by inoculation. (Smith, Farmers' Bul. No. 17, Div. veg. Path., U. S. Dept. of Agr.)

Similar to the yellows is a disease known as "Rosette" from the peculiar tufts into which the leaf buds grow on trees under the influence of the disease. It attacks peaches and plums and is quite generally distributed over the northern portion of Middle Georgia, extending from Augusta to the Alabama line, and from Macon to some distance north of Atlanta. The writer has quite thoroughly worked the State over and has never found it south of Macon nor in extreme North Georgia. It also occurs, although to a limited extent, in Eastern Kansas and in Western South Carolina. It seems to be most prevalent in Georgia, where it has been known for about twenty years. It causes the destruction of many trees annually in infested sections of this State, but the growers do not consider it with any great dread from the fact that they effectively hold it under control by the destruction of all affected trees as soon as the disease appears. In some locali-

ties, however, rosetted trees have been left in hedges and waste places to propagate the disease and cause considerable destruction to adjacent orchards.

How to detect it.—Figure 7 well illustrates the appearance of a tree affected with rosette. This clustering together of the leaves into rosettes usually takes place in early spring and is one distinguishing character of the disease. The foliage assumes a yellowish green or orange color, or, in case of plums particularly a beautiful red color. The leaves have a straight, stiff appearance with inrolled margins. One season is usually sufficient to completely kill the affected trees. In some cases, however, a tree may live two years, especially if it is not attacked in all parts at once; but when a tree is once attacked it never recovers.

Prevention.—The same preventive measures suggested for yellows apply also to rosette, and particularly should all diseased trees be promptly dug up and burned. Fence rows and hedges where peaches and plums are growing should be watched and affected trees destroyed. By a series of experiments, Dr. Erwin F. Smith, of the U. S. Department of Agriculture, determined that it can be communicated by bud inoculation, it being necessary, however, for the tissues of the bud and stock to unite before inoculation is effected. Further than this its manner of spread is unknown. Dr. Smith suggests that possibly the disease may enter through the roots* but this has not yet been proved. It is certain, however, that it does spread naturally and that a few affected trees left standing in an orchard will in time cause the destruction of the entire orchard. Hence the importance of rooting up diseased trees.

MISTLETOE.

(Phoradendron flavescens.)

Nearly everyone is familiar with mistletoe. It is a shrubby plant parasitic on trees, especially oaks, elms, maples, willows, poplars, apples and pears. It possesses the remarkable property of firmly engrafting itself on the limbs of trees and subsisting on their juices. The stems are one and a half feet high, much branched, rather thick and brittle. The leaves

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*Farmers' Bulletin, No. 17, Div. Veg. Path., U. S. Department of Agriculture, page 17.

are thick, three-veined, obtuse, cuneate-obovate, smooth and entire on rather short petioles. The berry is white semi-transparent and has a viscous pulp adhering to the limb or branch with which it comes in contact until it strikes root.

This parasite feeds on the juices of the tree upon which it is growing and draws heavily upon its vitality. On germination it sends out numerous rootlets which penetrate the cortex of the host and even enter the wood with which they form an intimate connection. This causes local death and a hurtful influence throughout the plant. At the point of attack a distorted, swollen appearance is presented, due to the drying of the tissues and the process of repairing. Trees are so weakened by mistletoe that they are very much stunted in growth and in the course of time die limb by limb. It is common all over the State and is especially destructive to the shade trees in many of our cities. The Board placed it on the list of injurious pests that steps might be taken to check its destructive work on the shade trees of the cities. The shade trees of Augusta particularly have suffered from this pest, and many of them are gradually dying from its weakening influence, together with the attacks of some scale insects. At the time of this writing the writer receives a communication from the Civic League, of Augusta, asking for a treatment for the shade trees of that city against mistletoe and scale insects. Apple and pear trees are also hosts for this parasite, but because of the more thorough course of pruning and better treatment otherwise given them than is usually given shade trees they do not suffer so severely from its attacks.

Treatment.—Mistletoe can be quite effectively controlled by keeping it cut off. Where it appears on the smaller branches they should be pruned off and the bunches occurring on large limbs should be chipped out. This can be done in the fall or early winter, and the plant should never be allowed to remain on the trees until the fruit ripens. The berries scatter and the pulp being viscous they adhere to whatever they touch. Birds, particularly the thrush, feed on the berries and are effective agencies in disseminating the seed, especially in wiping their bills on limbs and thus leaving berries that have adhered to them.

In conclusion, I wish to acknowledge, with pleasure, the valuable services of Miss Mamie Griggs in producing the drawings for figures 3, 4 and 5.

Bulletin No. 2.
[redacted]

Jan. 15, 1901.

GEORGIA
STATE BOARD OF ENTOMOLOGY.
ATLANTA, GA.

Spring Treatment of Orchards Infested With the San Jose scale.

By W. M. SCOTT, State Entomologist.

a *b*

[Fig. 1. Appearance of the scale on bark: *a*, infested twig, natural size; *b*, bark as it appears under hand lens, showing scale in various stages of development, and young larvae. (Howard and Marlatt, Bul. No. 3, New Series Div. of Entomology, U. S. Dept. of Agriculture.

Through correspondence and personal visits all of the fruit growers of Georgia that our records show to have trees infested with the San Jose scale have been given instructions upon the means of controlling it; but unfortunately some fruit growers are prone to procrastinate and mid-winter has found a number of infested orchards yet unsprayed. The line of treatment that I have insisted upon calls for two winter applications, one im-

mediately after the foliage is shed and the other in late winter or spring before the trees bloom.

It should be remembered that spraying can be done without injury to the trees only in fair weather, and during the winter the number of days suitable for spraying is quite limited. Hence the importance of beginning operation in the fall. If spraying is delayed until spring, weather conditions usually make it impractible to get over a large orchard with two applications, and in some orchards last year the trees were blooming before the first spraying had been completed. After the trees begin to bloom spraying must cease until the crop is gathered. To spray trees in bloom means destruction to the crop ; to spray trees in fruit means a kerosene flavor for the fruit ; to neglect the treatment of a peach or plum orchard for two years means the partial or entire destruction of the orchard ; to successfully control the San Jose scale means the application of all the energy and enterprise the fruit growers can muster.

We have had an unusually mild winter and the San Jose scale has been breeding on warm days throughout the winter up to the present. In this respect the weather has been most favorable for the destruction of the scale. When breeding and in an active condition the scale is more susceptible to treatment than when in a dormant condition. Do not delay treatment longer ; utilize every favorable day in the fight for the mastery of this pest until your infested orchards have been thorougly sprayed.

Many of the growers have already completed the first winter spraying and it will be necessary to repeat the application only in orchards that are badly infested throughout. In orchards where the infestation is apparently limited to small areas all trees that show the presence of scale should receive the second application, while the general treatment of the orchard may be limited to one application. It is a mistake, however, to attempt to select and spray the infested trees and entirely omit the general treatment of the orchard. It is an equal mistake to attempt the eradication of a case of scale from an orchard by destroying all trees that show the presence of the scale, omitting those that are apparently free. No manner of inspection will reveal all the infested trees in a large orchard.

While it must be admitted that the San Jose scale in a permanency in Georgia, there is no longer any doubt that it can be successfully controlled without menacing the profitable production of fruit to any large extent. Our experience during the past three years has shown conclusively that this pest will yield to proper treatment and that infested orchards can be kept in fair condition. The records of this Department show that orchards containing ten to fifty thousand trees badly infested with scale three yeers ago are now in good condition. It required thorough work to preserve these orchards but the results have fully justified the efforts. It is true that a very small per cent. of the trees referred to have died from the combined effect of the scale and the severe treatment, but this has only slightly disfigured the orchards without causing any appreciable loss.

Directions for treating scale infested orchards have been repeatedly placed in the hands of our fruit growers, but it will hardly be out of place to give them here with particular reference to spring work.

Digging up Infested Trees.—A newly established case of scale in a neighborhood formerly free may be exterminated by the destruction of all trees involved. By such heroic treatment a neighborhood may be freed from this pest, provided it is discovered and the trees destroyed within a few months after its introduction. Aside from cases of recent and limited infestation the digging up method is resorted to only where there is strong hope of preventing or delaying the spread of the scale to neighboring orchards. By a prompt destruction of a few hundred trees under certain conditions the progress of the scale may be materially checked and its spread over an important fruit section delayed two or three years. Under any circumstances all trees in a dying condition and beyond recovery should be dug up.

The Kerosene-Water Treatment.—After repeated experiments with various substances, considering cost, danger of injury to the trees and fruit buds, and effectiveness against the scale, we have found that the kerosene-water treatment gives the most satisfactory results. For the application of this remedy is required a spray pump specially fitted to mechanically mix kerosene and water in the act of spraying. These machines are so constructed that the desired percentage of kerosene can be regulated quite accurately.

The Goulds "Kero-Water" pump, made by the Goulds Mfg. Co., Seneca Falls, N. Y.,* has given general satisfaction with us and has proved more reliable than other pumps tested.

During the winter of 1898-99, upon my recommendation, a 25 per cent. strength of kerosene was generally used in the State, and while the results were in the main satisfactory, careful experiments showed that a 20 per cent. strength accomplished about the same results against the scale and was attended with less danger of injury to the trees. For two years, therefore, we have been using the 20 per cent. kerosene-water mixture as a winter treatment. As stated above, an infested orchard should receive at least one annual application and in bad cases two applications during the course of the winter are required to bring the scale under control. The spraying may be done at any time during the winter, but one should begin in time to finish the work before the trees begin to bloom. If two applications are to be made, it is a good practice to make the first early in the fall as soon as the foliage is shed. At that time in this climate the insects are still in an active condition and much more readily destroyed than later when they become dormant. It is true that the danger of injury to the trees is less in late winter or spring, but I have never observed any particular damage from fall spraying.

The mixture should be applied in a fine mist and every portion of the

*These spray pumps are now kept in stock by the Mallary Mill Supply Co., Macon, Ga.

infested tree should be moistened from the ground to the tips of the twigs, but care should be taken not to allow the mixture to run down the trunk and collect about the base of the tree. It should always be borne in mind that an excess of the mixture applied to a tree will in many cases produce death, particularly to peaches and plums. The usual caution to avoid spraying on damp and cloudy days should be observed; neither should spraying be continued in the evening after sunset. The conditions should always be favorable to a rapid evaporation of the kerosene, else injury to the trees may result.

For summer treatment a 10 per cent. strength of kerosene with water is recommended. This is very useful to check the progress of the scale in an orchard that has not formerly been properly treated, until a winter application can be made. A particularly favorable time for its application to peach and plum trees is immediately after the crop is gathered. The scale is then about at its maximum breeding rate and the application will largely destroy the young larvae and the breeding females. Not over 10 per cent. kerosene should be used, and the leaves should not be left dripping. In our experiments with this remedy it was noted that, notwithstanding great care, some of the peach leaves were scorched around the margins and "shot-holed"; but this slight injury apparently did not result in permanent damage to the trees.

The Crude-Petroleum Treatment.—Crude petroleum can be substituted for the refined oil in the spring treatment of the San Jose scale. It should be applied in mechanical mixture with water in exactly the same way as kerosene is used and with the same cautions. In our experiments with this substance it was quite definitely determined that a 25 per cent. strength was safe to use on peach and plum trees and that the crude petroleum was even more effective against the scale than the same strength of the refined kerosene. The pure crude oil and mixtures of a strength greater than 50 per cent. either killed or severely injured all trees sprayed. It was not found necessary, however, to use over 25 per cent. to destroy the scale. The oil remains on the sprayed tree two or three months and evidently prevents the young insects from attaching themselves to the bark. It, therefore, acts as a preventive as well as a curative.

Only peach and plum trees were used in the experiment and the applications were made early in March, 1900 before the trees bloomed. The experiment was continued through the summer and fall, but the results do not warrant the recommendation of even a small percentage of crude oil on peach foliage Trees sprayed in July with a 10 per cent. strength were considerably damaged. The result of our fall and early winter applications are not favorable. I can, therefore, commend the use of crude petroleum on peach and plum trees only for late winter and spring. It should be explained, however that there are many different forms of crude petroleum and while one article might damage a tree another used under the same conditions would not. The lighter paraffin oils are to be recommended in preference to the heavier oils.

GEORGIA

State Board of Entomology,

BULLETIN NO. 3, JULY, 1901.

INSPECTION AND CERTIFICATION OF NURSERY STOCK.

BY

W. M. SCOTT.

CAPITOL BUILDING, ATLANTA, GA.

Georgia State Board of Entomology.

O. B. STEVENS, Chairman, Commissioner of Agriculture, Atlanta.

P. J. BERCKMANS, Pres. of State Horticultural Society, Augusta.

J. POPE BROWN, ... Pres. of State Agricultural Society, Hawkinsville.

W. M. SCOTT, ... Entomologist and Sec. of the Board, Atlanta.

W. F. FISKE, ... Assistant Entomologist, Atlanta.

To the Honorable Board of Entomology of the State of Georgia.

Sirs: I have the honor to submit the accompanying manuscript for publication and distribution in accordance with an Act of the General Assembly of Georgia, approved December 20, 1898.

This proposed publication seeks to clear up apparent confusion among the nurserymen, particularly those in other States doing business in Georgia, concerning the requirements of the law and rules and regulations of the board governing the inspection and transportation of nursery stock and to show our position with regard to the enforcement of the same. Last year some trouble was encountered with outside nurserymen and it is hoped that, our position being understood, such trouble will not recur.

It is thought proper to place the instructions to the Georgia nurserymen and to those outside of the State under the same cover, so that there may be a mutual understanding as to what is required of each.

Very respectfully.

W. M. Scott,
State Entomologist.

I. To Georgia Nurserymen.

The law governing the inspection and certification of nursery stock prescribes that the annual inspection of nurseries shall be completed on or before November 1st of each year; but the execution of the Act, as concerns the detail of the work, is left largely to the discretion of the entomologist. The time of the inspection last year was, from necessity, extended through the month of November and, indeed, a few unimportant inspections were made as late as December. The recent addition of an assistant to the working force will greatly facilitate the work in the future, and the inspection this season will doubtless be completed within the prescribed time.

The regular inspection work is not begun until August 15th, but the business methods of a few nurserymen require an earlier inspection, and in such cases the inspections may be made as early as the first of July. An inspection made before the 15th of August, however, must be supplemented by another later in the season. The reason for delaying the work as late in the season as practicable is apparent when the life history and habits of the San Jose scale are considered, this being the principal pest for which the inspection is made. In this climate the scale is breeding and is capable of being communicated to the nursery, certainly as late as November. A certificate issued upon an early inspection, therefore, would give little or no assurance of the absence of scale from the nursery, particularly where it is located in an infested neighborhood. Moreover, June budded peach trees will not have made sufficient growth to admit of a satisfactory inspection before October. It is clear, too, that insect injuries and disease effects are more conspicuous near the close of the growing season.

A certificate at best does not give unqualified evidence of the entire absence of seriously injurious insects and diseases. It is proposd, therefore, to make the inspections under the most favorable conditions and to make supplemental inspections after the stock is dug, wherever the surroundings are such as to cause suspicion. As complete an assurance as possible of the cleanliness of the stock is thus obtained, and it is hoped that there may be established, thereby, a confidence in the products of the Georgia nurseries equally advantageous to the nurserymen and orchardists.

Some nurserymen have a careless habit of leaving old, unsalable stock heeled in on their yards from year to year. This practice affords a harboring place for insects and diseases and we strongly condemn it. A case in point: Last year the writer found San Jose scale in a bunch of old stock heeled in on the yard of one of our nurserymen; and, although no scale could be found in the nursery blocks, the regular certificate could not be issued to the

owner. Wherever such conditions are found our certificate will be withheld until they are corrected.

Aside from the San Jose scale the following are on the Board's list of dangerously injurious pests: The New Peach Scale, Black Knot, Peach Yellows, Peach and Plum Rosette. None of these have yet been found in any of the nurseries, but with the exception of the Yellows they all occur in the State to a slight extent and are carefully looked for when the inspections are made.

Last year seventy nurseries were inspected, four of which were found infested with San Jose scale and from the owners of which the regular inspection certificate was withheld. It should be clearly understood here that no nurseryman whose premises are found infested can obtain the regular certificate. A nurseryman, a portion of whose premises is infested, but in such a manner as not to endanger the remainder, may be given a *special certificate;* provided, however, that all stock growing in the infested portion shall be destroyed and the remainder fumigated under our personal supervision. Likewise, where a nursery is located in a scale infested neighborhood, even though no scale can be found on the nursery grounds, fumigation will be required and a certificate will be given to the owner of such a nursery only upon the conditions expressed in writing that he will fumigate every plant before it is sent out. This requirement is based upon the following rule of the rules and regulations adopted by the Board of Entomology, January 18, 1899:

RULE 9.—The State Entomologist shall have power to require any nurseryman of the State to fumigate his stock with hydrocyanic acid gas, when in his judgment the presence of any pest in the nursery or in the neighborhood of the nursery warrants such treatment for the better protection of the agricultural interests of the State. Upon failure of any individual, firm or corporation to comply with this requirement, the State Entomologist is hereby authorized to withhold his certificate from the same.

Some of our nurserymen, even though not compelled to meet the above requirement, have voluntarily adopted the plan of fumigating all stock (including buds and grafts) grown or handled by them. We most urgently advise all nurserymen to adopt this plan, not only as a precaution against the San Jose scale, but to destroy the Woolly Aphis and other injurious insects liable to be conveyed on nursery stock.

The State of Virginia has placed the official ban upon the Woolly Aphis and Crown Gall, and other States are bringing gradual pressure to bear for the reduction of these pests. The regulations of our State Board make no provisions for the disposition of stock infested with the Woolly Aphis or Crown Gall, leaving it to the discretion of the inspector.

Our own observations in the orchards of the State show these agencies to be seriously injurious, either producing death or greatly retarding growth of affected trees. For some time it has been a question as to what action should be taken with regard to these troubles, and so far nurserymen have only been requested to withhold from the market all affected stock. In the future we

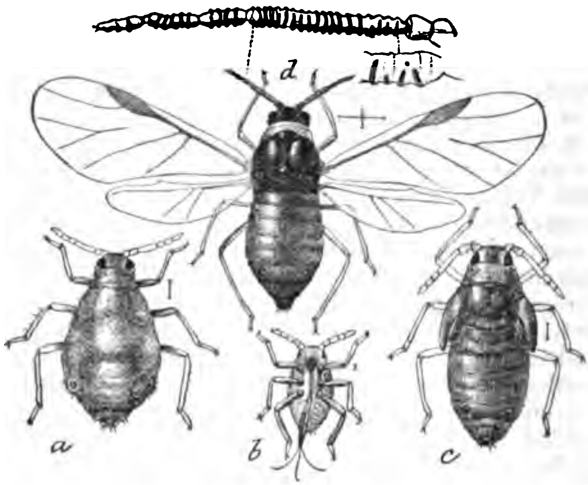

Fig. 1.—Woolly aphis (*Schizoneura lanigera*). *a*, Agamic female; *b*, larval louse; *c*, pupa; *d*, winged female with antenna enlarged above; all greatly enlarged and with waxy excretion removed. (Marlatt, Circ. No. 20, sec. s., Div. of Ent., U. S. Dept. of Agr.)

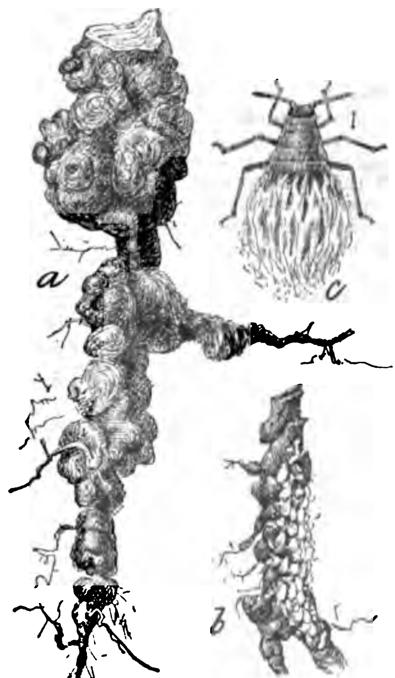

Fig. 2.—Woolly aphis (*Schizoneura lanigera*). *a*, Root of young tree illustrating deformation; *b*, section of root with aphides clustered over it; *c*, root louse, female—*a* and *b*, natural size; *c*, much enlarged. (Marlatt, Circ. No. 20, sec. s., Div. of Ent., U. S. Dept. of Agr.)

FIG. 3.—Crown-Gall (*Dendrophagus globosus* Toumey). 1, gall on Mariana Plum cutting; 2, gall at crown and on root of Elberta Peach; 3, gall on Peach induced by planting diseased Mariana Plum in juxtaposition; 4, gall induced by inoculation. (A. L. Quaintance, photo., Proc, 24th Ann. Meeting Ga. St. Hort. Soc).

will require the destruction of plants visibly infected with Crown Gall, and all apple trees sufficiently infested with the Woolly Aphis to show knots on the roots. In cases of slight infestation by the Woolly Aphis only fumigation or whale oil soap treatment will be required.

At the time of the regular inspection it will not be possible to determine the extent of these pests in the nurseries, as the roots will not then be exposed and only a few trees in each block can be pulled up for examination. Then, after all, we must depend largely upon the honesty and integrity of the nurserymen for the enforcement of our instructions. In this connection it should be stated that we have had the hearty co-operation of the Georgia nurserymen in our work and it is largely due to them that the law has been successfully executed.

In addition to fruit trees the following, if offered for sale, are classed as nursery stock and are subject to the regulations governing the inspection and transportation of the same: Strawberry plants, vines, ornamental trees and shrubs, and greenhouse plants (not including cut-flowers).

The following is the form of the certificate issued to nurserymen whose premises conform to the requirements of the Board:

GEORGIA STATE BOARD OF ENTOMOLOGY.

ATLANTA, GA.

OFFICIAL CERTIFICATE. No. . .

TO WHOM IT MAY CONCERN:

This is to certify that in accordance with an Act of Assembly approved December 20, 1898, I have on the.............days of ....made an inspection of the nurseries of .... at ....and that I found the stock in these nurseries apparently free from the San Jose scale and all other insects and diseases of a seriously injurious nature ....

....

This Certificate is to cover only stock grown in the above-named nurseries, and becomes invalid twelve months from date.

....

State Entomologist.

When it is desired to use this certificate on stock other than that grown by the nurseryman to whom it was issued, it may be so used provided such stock is already covered by our State Certificate or the official tag of the Board issued to nurserymen outside of the State.

The regular inspection certificate must not be used by dealers in nursery stock who are not themselves growers. Buying and re-selling plants is certainly a legitimate business and we have

made provision whereby dealers may readily comply with the law. The dealer must furnish this office with the names of all the nurserymen from whom he proposes to purchase stock, and if our records show that all of them have met with the requirements of the Board, a certificate to that effect will be granted. Also wherever practicable the stock handled by dealers will be re-inspected.

All nursery stock offered for transportation must be plainly labeled with the official inspection certificate in accordance with the following rule of the Board:

Rule 4.—Any trees, shrubs or other plants commonly known as nursery stock, shipped within the State of Georgia, without each box, bundle or package (in each car load, or less than car load lot) being plainly labeled with an official Entomologist's certificate to the effect that the contents of the same have been inspected and found to meet with the requirements of the Board of Entomology, in accordance with section 10 of the act cited above, shall be liable to confiscation upon the order of the inspector.

Any nurseryman upon application to this office, with dimensions of his fumigating house, will be furnished the formula and full instructions for fumigating. When desired, if necessary, we will personally superintend the beginning of the work.

The formula that we have adopted is 1 ounce of potassium cyanide (98-99 per cent), 1 1-4 ounces of commercial sulphuric acid, 3 ounces of water to every 100 cubic feet of space in the room; time of exposure 50 minutes. Our experiments have shown that the time may be extended to one hour without danger of injury to dormant trees.

We wish to give notice here that all fumigating houses should be placed in order for approval at the time of nursery inspection.

So far as possible the nurseries will be taken up systematically with respect to location, in order to avoid traveling over the same ground more than once. It is hoped that demands for early inspections will not materially interfere with this plan; but when for any good reason, a certificate is desired in advance of our schedule we will arrange for an earlier inspection.

II. To Nurserymen of Other States and Countries Doing Business in Georgia.

Although the present regulations governing the transportation of nursery stock from other States and countries into Georgia have been in force since January, 1899, there still remains some confusion as to their provisions. Every year considerable trouble arises in the enforcement of our law, which usually results in delay in the delivery of the stock involved, if not total loss of the same. We make no attempt to quarantine against healthy nursery stock grown in other States, but on the contrary we invite legitimate trade from outside nurserymen and only ask that they comply with the simple provisions of our State law.

Our position can best be explained by quoting Section 13 of the Act of the General Assembly of Georgia, approved December 20, 1898, and rules 5, 6, 7, 8, and 9 of the rules and regulations of

the Georgia State Board of Entomology adopted under that Act:

SECTION 13.—Each and every person residng in states or countries outside of the State of Georgia, dealing in or handling trees, plants, cuttings, vines, shrubs, bulbs and roots in this State, shall register his name or firm and file a copy of his or its certificate of inspection furnished by the Entomologist, Fruit Inspector or other duly authorized government official of his State or County, with the Chairman of the Board of Control. Upon failure so to do, said stock shall be liable to confiscation under order of the Inspector.

RULE 5.—Each and every box, bundle, or package of trees, shrubs and other plants commonly known as nursery stock, shipped in car load lots or less than car load lots, into the State of Georgia from any other State or Country, shall be plainly labeled with a certificate of inspection furnished by the Entomologist, Fruit Inspector or other duly authorized official in the State or Country in which said stock was grown, and also with the official tag of the Georgia State Board of Entomology hereafter provided for; said certificate and tag to be valid for only twelve months from the date they bear, in accordance with Section 9 and 13 of the Act cited above. Such shipments not so labeled shall be liable to confiscation upon the order of the Inspector.

RULE 6.—Upon the filing of the proper certificate as above prescribed in accordance with Section 13 of said Act, and upon request of any person or persons residng in States or Countries outside of the State of Georgia, dealing in or handling trees, shrubs or other plants in this State, the certificate of the said Board of Entomology will be issued to the same without charge, and official tags bearing a *fac simile* copy of such certificate and the seal of the State Board, will be furnished such applicants at cost, viz.: Sixty cents for the first hundred or part thereof and twenty-five cents for each additional hundred.

RULE 7.—No transportation company or common carrier shall deliver any box, bundle or package of trees, shrubs or other plants commonly known as nursery stock, shipped from any other State or Country to any consignee at any station in the State of Georgia, unless each box, bundle or package is plainly labeled with a certificate of inspection furnished by the official Entomologist of the State or Country in which said stock was grown, and also with the official tag of the Georgia State Board of Entomology hereinabove provided for.

RULE 8.—Transportation companies shall immediately notify the State Entomologist (Atlanta, Ga.), when by oversight, negligence or otherwise, any shipment of uncertified stock is received at any station or wharf in the State, and it shall be his duty to proceed as speedily as possible to investigate and dispose of such stock, as provided for in the Act cited above.

Guided by rules 7 and 8, the transportation companies of the State have greatly assisted us in the enforcement of the law. It is clear that shipments of uncertified stock could not be readily detected without the co-operation of these companies, and we take occasion here to acknowledge our obligation to them. In addition to this, however, during the shipping season we make personal visits to the principal distributing points for the purpose of inspecting nursery stock entering the State; also, voluntary assistance is rendered by members of the State Horticultural Society, who report any suspicious shipments that may come under their observation. With our forces thus organized, failure on the part of any nurseryman to observe the law will usually be detected. We hope, however, that upon a better understanding of our position, further trouble of this nature may be avoided.

The official tag provided for in the rules quoted above reads substantially as follows:

GEORGIA STATE BOARD OF ENTOMOLOGY.

ATLANTA, GA.,................

OFFICIAL CERTIFICATE. No. ..

TO WHOM IT MAY CONCERN:

This is to certify that the certificate of..............Inspector for the State of ....has been filed with the Georgia State Board of Entomology, stating that the nursery stock grown in the nurseries of ....at ....was inspected on .... and found to conform with the requirements of this Board.

This certificate is invalid after ....

....

State Entomologist.

We make this tag valid for twelve months from the date of inspection, as shown in the certificate upon which it is based, unless the certificate is limited to less than twelve months, in which case our tag is given the same limit. It is intended, however, that these tags shall cover only the fall shipments of the current year and the following spring shipments.

It is our policy to accept, without discrimination, certificates of other States issued by authorities *legally constituted for that purpose,* as a basis for the official tag of the Board; but we reserve the right to withhold the tag from any nurseryman who is known to be handling diseased or infested stock, even though he holds a clean certificate. A case in point: In the spring of 1900 a nurseryman shipped into this State stock infested with San Jose scale under his State certificate and our tag. In due season again he filed his renewed certificate in this office with application for official tags to cover the following fall and spring shipping season. We refused to issue the tags upon the ground that the applicant had sent out scale infested stock from his nursery in the early part of the same year. Not being satisfied with our ruling, he unfortunately undertook to fill his Georgia orders without tags; and not until we had destroyed some 30,000 trees for him was he convinced that our law was effective. We hasten to explain, however, that these trees were examined and found to be infested with San Jose scale before they were destroyed, and that whenever by oversight the tag has been omitted from a shipment which proves, upon inspection, to be in good condition it will ordinarily be released.

The owner of the trees destroyed, in the case cited above, proposed to bring suit to recover damages and we submitted the case to the Attorney-General of Georgia, who rendered the following decision:

STATE OF GEORGIA,

ATTORNEY-GENERAL'S OFFICE,

ATLANTA, GA., Nov. 12, 1900.

Mr. W. M. Scott, State Entomologist, Atlanta, Ga.

DEAR SIR:—Replying to your request of this date will say that under the Act creating the State Board of Entomology, approved December 20, 1898, and the rules and regulations of the Board adopted in accordance therewith, the State Entomologist has authority to confiscate any and all nursery stock that may be shipped into this State unaccompanied by an inspection certificate and the official tag of the Board, even should such stock be not infested with dangerously injurious insects or diseases; and that he is authorized and it is his duty to destroy any and all nursery stock shipped into the State which is infested with the San Jose scale or other dangerously injurious insects, or infected with dangerously injurious plant diseases, without reference as to whether or not such stock is covered with an inspection certificate and the official tag of the Board. Yours very truly,

J. M. TERRELL, *Attorney-General.*

Whenever it is found that our tags are being used upon stock infested with *dangerously injurious pests,* they will be recalled from the grower of such stock or canceled by publicity.

For reasons explained in Part I. of this bulletin (which see), certificates issued upon inspections made prior to July 1st of each current year can not be accepted. Either the original certificate or a duplicate copy is desired. The nurseryman's printed copy will not be accepted.

For our position upon such troubles as the Woolly Aphis and Crown Gall we refer you to Part I, which gives the requirements placed upon the Georgia nurserymen, and so far as practicable we expect these requirements to apply to outside nurserymen doing business in Georgia.

With a few exceptions our relations with outside nurserymen have been of the most pleasant nature and we wish to assure them that, within the bounds of the law, we always stand ready to facilitate their trade in Georgia.

GEORGIA

State Board of Entomology

BULLETIN No. 4, SEPTEMBER, 1902

Winter Treatment of San Jose Scale in the Light of Recent Experiments

BY

W. M. SCOTT AND W. F. FISKE

COMPLIMENTS OF
THE AUTHORS.

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Georgia State Board of Entomology.

ORGANIZATION.

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P. J. BERCKMANS...President of State Horticultural Society, Augusta.

DUDLEY M. HUGHES, President of State Agricultural Society, Danville.

W. M. SCOTT........Entomologist and Secretary of the Board, Atlanta.

W. F. FISKE.............................Assistant Entomologist, Atlanta.

To the Honorable Board of Entomology of the State of Georgia:

SIRS:—I have the honor to submit the accompanying manuscript for publication and distribution in accordance with an Act of the General Assembly of Georgia, approved December 20, 1898.

The subject-matter consists principally of the results of a series of experiments with remedies for the San Jose scale, carried out during the past winter at Marshallville and Fort Valley, Ga., to which are appended directions for the preparation of the insecticiadal substances mentioned and recommendations for the treatment of infested orchards.

The San Jose scale continues to be the most serious insect enemy of the peach in Georgia, and it is hoped that by means of the experiments begun last winter, any doubts now existing as to the best and safest treatment for infested orchards will be definitely settled.

Very respectfully,

W. M. SCOTT,
State Entomologist.

Atlanta, Ga., September 1, 1902.

WINTER TREATMENT OF THE SAN JOSE SCALE IN THE LIGHT OF RECENT EXPERIMENTS.

BY W. M. SCOTT AND W. F. FISKE.

INTRODUCTION.

Since the discovery of the San Jose scale in the East many experiments have been made in search of a satisfactory remedy for it and practically every substance that, from the nature of the insect, gave promise of relief has been tested in one form or another. The question of treatment for nursery stock, or other plants that could be conveniently brought into an enclosure was early settled, hydrocyanic acid gas proving quite efficient; but the struggle for a remedy that would give entire satisfaction in the treatment of infested orchards has continued and it cannot yet be said that the desired end in all particulars has been reached. The great desideratum has been to make an application that would effectually destroy the scale insects without damaging the trees or endangering the fruit crop. The susceptibility of such plants as the peach to injury from applications of a sufficient strength to kill the scale, and the difficulty with which protected portions of a tree are reached, have made this an almost insurmountable problem.

Unfortunately the results obtained by workers in different sections of the country conflict to such a degree as to usually restrict their application to limited areas. This has necessitated a multiplicity of experiments, in order to determine what remedy is best suited to particular sections. The variability in results has perhaps been greater from the use of petroleum oils than from any other substance. Applications of oils in different localities of the same State have produced conflicting results. Even individual trees in the same orchard are oftentimes affected differently.

The reason for this is not altogether clear, but it is highly prob-

able that the physiological condition of the plants, as well as that of the insects, would afford at least a partial explanation. Moreover, there is frequently a difference in the composition of what is supposed to be the same insecticide obtained from different sources. There are probably no two localities that furnish petroleum identical in chemical composition, and even the oil from one well may not always remain constant in this respect. It would appear therefore that the services of both a physiologist and a chemist are greatly needed to assist in the solution of the problem at hand.

For several years the petroleum oils have taken the lead as a remedy for the San Jose scale in the East, and they have perhaps been more extensively used in Georgia than in any other State, more than half a million trees having been sprayed with oils here during last winter alone. The results from the use of both kerosene and crude oil, in this State, have been satisfactory upon the whole, but occasional damage to the treated trees, as well as lack of effect against the scale, has resulted from applications of the recommended 20 per cent. strength. In most cases, however, these adverse results are traceable to defects in the pumps, carelessness of the operators in making the application, or other causes more or less within the power of the orchardist to control.

Perhaps whale-oil soap, though varying greatly in its effect upon both the scale insects and the fruit buds in different sections, has given more uniform results the country over than any other substance used. For a few years it was the accepted remedy in many sections, and is still given the preference by some workers. It has been very little used in Georgia and has never gained any prominence as a scale remedy here.

The California lime, salt and sulphur wash has been for many years extensively used on the Pacific coast as the favorite remedy for the San Jose scale. Early experiments with this wash in the East did not show good results, and until recently it has been supposed that climatic conditions rendered it valueless here. However, recent experiments have thrown more light upon the nature and effect of this treatment and it now promises to become an efficient remedy in the Atlantic, as it is in the Pacific States.

Such insecticides as the resin wash and caustic potash have also taken part in the struggle against the scale, with varying degrees of success. Aside from these better known scale remedies the

fruit-growers have been invaded with venders of various "sure cure" washes and compounds with the usual guarantee attached.

It became necessary, therefore, to determine the value of these various substances in comparison with the oils officially recommended by the department, and for this purpose the experiments discussed herein were planned and executed. In order to place the work on a commercial basis and to obtain results that would be applicable to large orchards, each substance tested was applied to several hundred trees. Discrepancies likely to arise in practical work do not always become apparent in a test upon only a few trees, hence the greater value of practical experiments.

CONDITION OF THE TREES EMPLOYED.

For several reasons it was not deemed necessary to use other than peach trees in the experiments, although had it been convenient other kinds would have been included. With the exception of Le Conte and Kieffer pears, which do not appear to suffer from the attacks of scale, the peach and plum are the only fruits extensively grown in the State. Former experiments have shown that the plum is slightly less susceptible to injury from insecticide applications than the peach and that it is capable of taking the same treatment without risk. A few cases of infested apple orchards exist in North Georgia, but safe remedies for infested peach trees can be used with equal effect and safety upon the apple. Hence recommendations for the treatment of infested plum and apple trees can be based on results obtained in the peach orchard.

The experiments were conducted in two orchards, both located at Marshallville, Ga. One, owned by Mr. S. H. Rumph, was two years old and contained 17,000 trees, and the other, owned by Mr. F. J. Frederick, was four years old and contained about 2,000 trees.

The Rumph orchard was planted in February, 1900, and has since received such cultivation as the growth of cotton between the rows would allow. At planting time the trees were given the customary amount of fertilizer and have since had only such amount as they could obtain from that distributed in the cotton rows. The pruning has been light, merely the cutting out of superfluous branches and no heading back. The varieties composing

it are Triumph, Dewey, Waddell, Pansy, Red River, Tillotson, Carmen, Mountain Rose, Hiley, Slappy and Lady Ingold.

This orchard evidently became infested with San Jose scale from local spread within a few months after it was planted. It appears that cotton pickers, while at work among the trees, thoroughly disseminated the scale over the entire orchard on their clothing. They frequently left their work and went foraging for fruit in a neighboring orchard that was badly infested, thus establishing a continuous communication between the two orchards for about ten days. The infestation was so thorough that upon inspection less than 10 per cent. of the trees were found entirely free and from ten to forty trees in each plot of four hundred were either completely encrusted, or nearly so.

When the orchard was given to our charge for experimental work it had received no previous treatment for scale. The extent of infestation, the age of the trees and the large number of varieties combined to make this orchard an exceptionally desirable one for the experiment.

The Frederick orchard was selected more particularly with a view of testing the effect of the insecticides on the fruit buds, the Rumph orchard being too young to be expected to bear a full crop of fruit the following season. In varieties it consisted of Carmen, Belle of Georgia, Elberta and Emma. An inspection previous to treatment showed San Jose scale on nearly every tree, and about 25 per cent. were badly infested. Scale had been found in the orchard the previous year but no treatment had been applied, and as a consequence a few trees had died. Aside from the effect of the scale both orchards were in a vigorous condition and well supplied with fruit buds.

CONDITION OF THE SCALE INSECTS.

The natural life of the San Jose scale being only about ten weeks for the female and less for the male, very few that had reached maturity during the summer would be expected to pass the winter alive. Our observations in connection with the experiments showed that all but a very small per cent. of the mature insects that began the winter alive, died without treatment before spring. Moreover, examinations of check trees in early spring revealed the fact that at least 30 per cent. of the immature

scales had also perished during the course of the winter. The cause of this fatality among the half-grown insects that should normally pass the winter in good condition is not known. In accounting for a similar occurrence in Illinois* Dr. Forbes suggests that it might be attributable to a severe drouth of the preceding year. This would hardly explain the occurrence here, as the trees in the test orchards were not subjected to a drouth of sufficient severity to be materially affected.

PERIOD COVERED BY THE WORK.

It was intended to divide the work into fall, winter and spring, and thus triplicate the experiments with each substance, but delay in obtaining some of the materials and apparatus interfered somewhat with this plan. On November 30th, 1901, the work was begun and it was continued at intervals, as the weather would permit, through December, January, February and up to March 7th, when the most advanced buds were beginning to part their petals.

The weather conditions in their relation to the results will be recorded with the details of the experiments. For the purpose of testing summer washes the experiments were taken up again in July of the present year, but results from the summer work cannot be reported at this time.

Beginning in March, notes upon the results were taken at several different times until August, during which month the last observations were made. Had conclusions been drawn from the early observations alone the recorded results would have been different. In August, after the insects had been breeding for some time, the observations were obviously more practical. By actually counting the dead and living scales the percentage of fatality could be more readily approximated in early spring, but after the insects had passed through a portion of the breeding period the actual conditions could be more accurately determined.

SUBSTANCES EMPLOYED.

It was desired to cover the field of known and promising remedies as completely as possible, but owing to the extent of the undertaking and failure to secure some of the substances, a portion

* Bull 71, Univ. of Ill., Agr. Exp. Station.

of the tests originally planned for had to be omitted. It is particularly unfortunate that the Beaumont oil was not tested. Repeated attempts to secure this substance resulted in failure, until too late to make the application. However, this oil, together with other substances, will be tested next winter in the continuation of these experiments. The substances actually used in the tests may be classified as follows:

Oils:—

Pennsylvania crude, 43° gravity,
Refined kerosene, 150° flash test,
Ohio crude (fuel oil),
California Distillate.

Soaps:—

Leggett's Anchor Brand,
Leggett's Whale-oil Soap Compound,
Good's No. 3,
Good's No. 6, Tobacco.
Turpentine Soap.

Caustic Washes:—

Lime, Salt and Sulphur,
Crude Caustic Potash,
Resin Wash,
Carbolic Acid Emulsion.

GENERAL STATEMENT OF THE WORK WITH CONCLUSIONS DRAWN FROM THE RESULTS.

It is not the purpose of this paper to give the details of the experiments and the percentages of fatality among the scale insects produced by the insecticides, but rather to record such conclusions, reached from the results, as will be of the most value to the fruit-growers in the treatment of their orchards.

The Rumph orchard was divided into plots of 400 trees each, and these plots were so arranged that each contained at least five varieties of peaches, and from 10 to 40 badly infested trees. In repeating applications it became necessary to subdivide some of the plots, using only 100 or 200 trees to the test. In the Frederick

orchard the size of the plots ranged from 25 to 150 trees, with an abundance of scale throughout each plot.

PETROLEUM OILS.

Kerosene, in mechanical mixture with water, was for several years the chief remedy recommended by this department for the San Jose scale, but experiments begun in the winter of 1899–1900, indicated that crude oil was slightly more effective and less dangerous. For two years, therefore, the latter substance has been given equal rank with kerosene as a scale remedy here; but the comparative value of the two oils, as well as a number of other points connected with their use as a spray, remained indefinitely settled. While it was not possible to cover the entire ground in one season, the results obtained from last winter's work have thrown considerable light upon the problems in hand.

The Pennsylvania crude oil used in the experiments was obtained in two lots, one from the Standard Oil Company, and the other from the Emery Manufacturing Company, Bradford, Pa. No distinction could be made between the oils in the two lots, both registering 43°—43½° gravity. The kerosene was bought locally, and was of the grade 150° flash test.

The observations taken between March and June inclusive, when actual counts were made of dead and living scales, were deceiving in some particulars. Two applications appeared to have but little advantage over one, and the results, upon the whole, were not consistent with what should have been expected. The August observations, however, cleared up many discrepancies, especially showing superior results from two applications. In making the earlier examinations, the small spaces missed by the spray were naturally overlooked in most cases, the portions best exposed being the more convenient for making counts to determine the proportion of dead to living scales. Hence applications that showed almost perfect results before the scale commenced breeding, proved to be inefficient when the August observations were made.

The Comparative Value of Crude Oil and Kerosene.—From our results it is impossible to make any decision other than that both kerosene and crude oil are good, and perhaps equally the best remedies that may be employed against the San Jose scale, when they are applied in the proper manner and with due precaution.

The results from two applications of either substance at strengths not lower than 15 per cent. were uniformly good, but single applications varied to a surprising degree in their effect upon the scale. In the course of the experiments in the Rumph orchard, single applications of kerosene were made to 11 plots, and of crude oil to 22 plots, strengths of 10, 15, 20 and 25 per cents. being used. In the majority of these plots the results were not satisfactory, when contrasted with those obtained from two applications. The extreme variation noticed between the results from single applications of the same strength made on different days, is difficult to account for. It occurred to an equal degree in both substances, but to a less extent when the mechanical mixture was replaced by emulsion. The working of the pumps, the weather conditions, and the season of the year, may all have had some influence, and occasional carelessness of the man at the nozzle must be considered one of the most important factors.

In the Frederick orchard, which it will be remembered consisted of older trees, the results were more uniform throughout. Both the refined and crude oil proved effective as a single application, and plots treated once with only 15 per cent. showed very little live scale in August.

In the Rumph orchard neither substance had any apparent damaging effect upon the trees, nor in the Frederick orchard, except when a few trees received an overdose of oil through fault in the action of the mechanical mixing pump. Therefore, so far as the actual observations upon the results indicate, the refined and crude oil may be considered equally effective, and as little or no damage was done to the trees by either, equally safe. But owing to the residuum with which the trees are left coated for several weeks by applications of crude oil, it would appear that in general practice this substance might prove more destructive to the scale than kerosene.

One versus Two Applications.—Here the results of our experiments speak most decidedly, and in favor of two applications as against one. In the Rumph orchard 8 plots were treated twice, and all, with a single exception, satisfactorily. A plot sprayed with 10 per cent. kerosene in emulsion and followed later with 15 per cent., was the exception, and even here the result was better than in several cases where 25 per cent., as one application, was used. A 15 per cent. strength of kerosene in emulsion, applied November

30th, followed by a 20 per cent. strength of the same on February 24th, gave as nearly perfect results as anything employed, and the same fall treatment, followed by 15 per cent. in February, was almost equally perfect.

In the Frederick orchard notes taken in August showed a noticeable superiority of two applications over one, though on account of the better results here obtained with a single spraying the difference was not so marked as on the younger trees composing the Rumph orchard.

The reasons for the additional effectiveness of two applications, even though the same amount of oil was used in a single one, are several. The most important is that in two applications the trees have a double chance of being entirely coated with the spray. It is not always practical to choose perfectly calm days for the work, and if there is considerable wind it is next to impossible to cover every part of the tree. Even under the best conditions, unless the hands that hold the nozzles are exceptionally good, a twig or a portion of a limb is likely to be missed occasionally, so that a second spraying is necessary to complete the work. Moreover it is certain that any strength less than 20 per cent. will not kill all the scales hit, and even 20 per cent. or 25 per cent. may fail to kill an occasional one, while two applications of even 15 per cent., or particularly 15 per cent. followed by 20 per cent., appear to be sure. There is also good reason to suppose that two weak applications have less injurious effect on the tree than one of greater strength, provided they are made at least thirty days apart to avoid the accumulative effect.

Fall versus Spring Spraying.—It was at first intended to carry out a series of experiments which should determine the relative values of fall, winter and spring spraying, but as has already been stated, it was found impossible to procure the apparatus and materials necessary for an extended experiment with oils before Christmas. A few plots sprayed in November and December, and a large number treated in January, were therefore compared with plots sprayed during late February and early March. Though the results of these later applications were not uniformly superior to those of the earlier, they proved on the whole to be distinctly better. A greater proportion of the scale were killed, and the spring-treated plots averaged freer when examined in August than

those plots sprayed with the same strengths and substances in the fall and winter.

Perhaps the most reasonable explanation of this is that the scale insects become more or less weakened by their long sleep through the winter months, and therefore withstand the action of the oil less effectually. On the other hand, it might be said that in the spring time they have begun to arouse themselves from their state of torpor, and even to grow a little, and that they are, for this reason, more susceptible to the effects of the spray. It is generally believed that the contrary is the case with the tree, which is supposed to be more easily injured by the use of oil during the winter months than after the flow of sap has begun in the spring, but no information on this point can be gleaned from the results of our experiments.

There are, none the less, strong advantages in the treatment of trees in the fall, which should not be lost sight of in this discussion. Scattered all through the Rumph orchard were trees badly infested with scale, even to the point of encrustation. When the last thorough examination of the experimental plots was made in August, it was noticed that such trees, when included in plots that had been successfully treated in the fall, and to a less extent in those sprayed in January, had thrown out a much stronger growth than in those that were left untouched until spring. In some instances there was as much difference as between a comparatively healthy tree in the one case and a dead tree in the other, and though often less marked than this, the superiority of the fall treatment was generally manifest. This must not be construed as an argument in favor of fall as against spring spraying, but rather for two applications of medium strength, one in the fall or early winter, and the other in the spring. This course of treatment gave results equal to any, and excelled by none, in our experimental plots.

Mechanical Mixture versus Soap Emulsion.—Kerosene emulsified by the use of soap, and variously diluted, has for a long time been one of the most popular and effective remedies against insects, especially scales and plant lice. Its rapidly increasing importance, and the trouble of preparing the emulsion, led to the manufacture and sale of several classes of pumps designed to mix the oil forcibly with the water in the act of spraying. These have been constructed on different principles, that employed by the Gould Man-

ufacturing Company and the Spraymoter Company proving the most satisfactory. It was thought that the problem was solved when it was demonstrated that these pumps could be made to work successfully, and the use of the emulsion on a large scale was therefore discontinued. It was soon found however, that though in the tests the mechanical mixing pumps could be made to give good results, in the field they were not always to be relied upon, and their complexity, besides rendering them more costly and less durable than the single barrel pumps, often caused undue delay for repairs. The results of the somewhat extensive experiments conducted with the view of testing the comparative value of soap emulsion and mechanical mixture indicate quite conclusively the superiority of the former in the destruction of the scale. In the form of emulsion a more even application can be made, thus reducing the danger to the trees and enhancing the effect.

Equally as good results were obtained from crude oil applied with the mechanical mixing pumps when a uniform discharge could be obtained. The Gould "kero-water" pump, with two leads of 20-foot hose, was used, and though apparently the best pump of this nature on the market, it cannot always be depended upon for a uniform percentage of oil. For some obscure reason the discharge of either oil or water may become obstructed at varying intervals, and even if this irregularity lasts for but a moment, a tree may be seriously injured, or the scale infesting it escape unharmed. Moreover, owing to the construction of the pump, a slightly greater percentage of oil is usually discharged through one lead of hose than the other; and with nozzles having small apertures (1-20 inch Vermorel were used), there is always some separation of the oil and water in the hose, and consequent variations in the composition of the spray from one instant to another. However, it should be explained, that with constant care and frequent tests, excellent results can be obtained by the use of these pumps.

This point settled, the question of comparative cost next arises, and this of course depends largely upon circumstances. On one side we have the added effectiveness, and when once prepared, the greater simplicity in manipulation of the emulsion, which stand as points in favor of its use against the added trouble and expense of its manufacture. On the other side is the lack of this trouble and expense, offsetting the lessened effect of the spray, the added

initial cost of the pumps and the trouble of keeping them in repair. All of these factors are more or less variable, and cannot be depended upon absolutely. Perhaps the only thing that can safely be said at this time is, that considering all things, there is no doubt but that in our experiments the oil was applied with equal cheapness in the form of emulsion, and certainly with less trouble.

The Strength of Oil Required to be Effective.—Tests were made with each of 10, 15, 20 and 25 per cents. strengths of both oils with varying results on different plots and in the two orchards. In the Frederick orchard the conditions of the scale and of the trees were such that the oil sprays proved much more effective than in the Rumph orchard. In the former 15 per cent. as a single application did satisfactory work. In the latter, although occasional plots sprayed with 20 per cent., and even with 15 per cent., under the best conditions, gave satisfactory results, only those sprayed with 25 per cent. averaged satisfactory, and some that were treated with this strength (during the winter) were found in August to contain an alarming amount of scale.

In summing up it would seem that the amount of oil to use would depend almost entirely upon circumstances. In the case of a young healthy orchard, thoroughly infested with scale, 25 per cent. would be required, and even this might not prove sufficient. In an older orchard, where the trees had practically reached their full growth and become in a degree resistant to the scale, 20 per cent., or perhaps even 15 per cent., if applied with great care and thoroughness, would prove quite effective. Two applications would be much better in either case, and would be almost a necessity in the former, if the Rumph orchard may be taken as typical. In such an orchard 15 per cent. in the fall, followed by 20 per cent. in the spring, would be the ideal treatment, and the spring spraying might be reduced in strength to 15 per cent. without serious detriment. In an older orchard two applications of 15 per cent. would certainly be sufficient.

The Influence of the Weather.—Rather to our surprise only negative results were obtained in the experiments to determine the effect of the weather which prevailed during the spraying of the various plots, unless, as is probable, the extreme unevenness of our results with single applications of oil, is due to the minor weather

conditions. Not a single tree in the Rumph orchard, so far as observed, was injured by either the crude oil or the kerosene. In the Frederick orchard some slight injury was done, which may have been due to cloudy weather followed by rain on the day of the treatment, but more likely to a temporary disorder of the oil-water pump used. In the Rumph orchard spraying was done under all sorts of conditions, except while rain was actually falling, but no logical connection can be traced between the weather conditions existing at the time of application and the final results. In the case of high winds the results, as would be expected, were less satisfactory, it being almost impossible to cover trees thoroughly with the spray under such conditions.

Too much stress must not be laid on these statements, however, as orchards have been repeatedly noted in the past in which trees sprayed under adverse weather conditions or late in the evening have suffered, while those receiving the same treatment at a more opportune time have passed through unharmed.

Tests with Ohio Crude Oil.—A barrel of oil from Ohio, designated by the Standard Oil Co. as fuel oil, was used on several plots with good success. The heavy residue of paraffine left after the evaporation was very noticeable, much thicker than that left after the evaporation of Pennsylvania crude oil, and probably owing to this peculiarity the effects against the scale were somewhat more marked. Several of the plots sprayed with the higher percentages of this oil presented a somewhat sickly appearance shortly after the foliage put out, and for a time some fear was felt as to their condition. Though they finally came through all right the circumstances would show that the use of this oil for spraying purposes is attended with too much risk to make its recommendation advisable, at least until after further tests.

California Distillate.—This is the product which is obtained by distilling oils with an asphalt base, like those of California and Texas. A quantity was obtained from California in the form of emulsion, which on arrival was found to have separated somewhat. It was re-emulsified as well as might be and sprayed on a plot of 200 trees at strengths of 10 per cent., 15 per cent. and 20 per cent., but with no better results than those obtained by the use of ordinary oils.

SOAPS.

Whale-oil soap is largely used in the North as a remedy against the San Jose scale, but its expense has to a large extent prohibited its use in the treatment of large orchards in Georgia. Occasionally however, in small family orchards, or in the case of a few trees in a garden lot, the question of expense is not so vital, and an application of soap may prove to be easier and safer than any other treatment of equal effectiveness. A number of experiments were therefore carried out to determine the comparative worth of soap and oil as a remedy for the scale. Several brands of soap were used and a number of applications were made from time to time throughout the course of the work.

Strength Required.—Only two strengths of the soap solution were used, viz.: 1½ lbs. and 2 lbs. to the gallon of water. Even under the best conditions the weaker solution was found to be unsatisfactory, although two applications at this strength, upon December 2d and February 28th, gave very good results, while single applications of 2 lbs. to the gallon on either date, proved very inefficient. Only the strength of 2 lbs. to the gallon on March 6th proved satisfactory.

Season of the Year and Weather Conditions.—For some reason none of the applications of soap made during the fall and winter were successful. It is impossible to determine from our notes whether this is entirely due to the season, to adverse weather conditions or to a combination of both. Every application, except those made in March, chanced to be followed almost immediately by more or less wet weather, which may have had the effect of washing the soap from the trees before its full effectiveness could be felt. The amount of rain in one or two instances was, however, so small that it seems stretching the point to account for all the ill results on this score, and there is not much doubt but that the season of the year had much to do with it.

Our results indicate that to be successful whale-oil soap must be applied as late as possible in the spring before the blossoms appear, and that to get the best results a day or two of fair weather should follow its application. This does not apply to the soda soaps, of which Leggett's Anchor Brand is an example.

Comparison with the Oil Treatment.—One application of a

potash soap, at the rate of 2 lbs. to the gallon of water, made under the best conditions as outlined above, gave as good results in all respects as single applications of 25 per cent. of either kerosene or crude oil, in emulsion or mechanical mixture. 1½ pounds to the gallon compared favorably with the average results attending the use of single applications of 20 per cent. oil, but cannot be recommended except possiby on old trees, such as had become partially resistant to the scale. Fall and winter applications gave results inferior to oils applied at the same time.

Results of Comparative Tests of Different Brands.—The whale-oil soaps tested were all potash soaps except Leggett's Anchor Brand. For several reasons this could not be called satisfactory. It is more difficult to dissolve, makes a thicker solution, so that if not applied quite warm is difficult to spray at the required strength, and also proves quite destructive to the fruit buds. However, this brand was superior to all the others in adhering qualities under the influence of rains, owing to which apparently its effectiveness against the scale was more marked. In fact 1½ pounds to the gallon applied December 2d, gave very fair results, and 2 pounds most excellent results, as far as the scale was concerned, but injured the buds quite seriously. Unfortunately the supply of this brand was exhausted in the fall and not replenished for spring use, so that our experiments can hardly be called complete. It is possible that 1½ pounds to the gallon might prove effective in the spring, and that no serious effect would follow its use at this season.

Leggett's Whale-oil Soap Compound, at the rate of 1½ and 2 pounds to the gallon, during the winter and early spring gave slightly better results than Good's Potash Soap at the same strengths.

Good's Potash and Tobacco Potash Whale-oil Soap were most extensively tested, as these proved easier of manipulation, dissolving with less difficulty and forming a better solution for spraying. The Tobacco Potash Soap (No. 6) did not appear to possess any advantage over the other; in fact the first notes indicated a little better results from the plain potash soap (No. 3).

The suggestion that a cheap grade of soap manufactured in Macon, known as "Magic Cleaner," might be effective against the scale was acted upon and a quantity of the soap purchased and

tested. It was found that not more than 1 pound to the gallon could be readily got into solution, and that at this strength it was far from effective.

Effect on Trees.—The general effect on the trees, with the single exception already cited, was rather beneficial than otherwise. The effect of the soap upon the bark was to clean off some of the outer dead portions and give it a smoother, more healthy appearance, and the tree generally seemed to be invigorated by the potash soaps. This is probably due in part to the slight fertilizing value of the soap, most of which eventually must find its way to the ground and the roots of the trees, as well as to its cleansing effect.

LIME, SALT AND SULPHUR.

This wash which has been for some years successfully used on the Pacific coast, was reported by experimenters in the East as unfitted for use here, on account of climatic conditions. Principally for this reason it has been neglected in most of the experiments made since in the endeavor to find the cheapest, surest and safest remedy for the scale.

Results Following its Use.—Four lots of the wash were prepared during the early spring and applied, three of them to the Rumph and one to the Frederick orchard. The results upon the scale were not, as is the case with oils and soaps, at once apparent. When first the coating began to crumble off the trees so as to allow the scale to become visible and permit of their examination, comparatively few of the insects were found to have been killed. Fifty per cent. on some trees were estimated to be living. Early in May a complete examination of all the plots was made, and at this date, although many of the scale had reached full maturity and begun to breed, above 10 per cent. were estimated on an average, to be still alive. Though the insect itself was apparently healthy in most of these cases, the scaly covering was corroded and imperfect, affording slight shelter, and the general condition was such as to make it appear that a second application would have completed the execution. In spite of the large percentage of living scale some encouragement was felt therefore, which was increased from time to time during June and July, when the plots were hastily passed through and very little scale noted as occurring upon the trees. Consequently

we were not totally unprepared for the surprise which the last examination in August had in store.

On August 12th and 16th the plots in the Rumph orchard were carefully examined and found to contain very few living scales, and these were often in anything but a healthy condition. In fact the results in one plot were as good as any obtained with two applications of kerosene in emulsion. In the other plots the work was not quite so thorough but was, none the less, superior to anything except two applications of kerosene or crude oil.

Comparison with Oil.—The advantages of lime, salt and sulphur over oil are several. Its cost per gallon ready to spray, counting only the material and using the California formula, would be from 1¼ to 1¾ cents, according to the strength used. Oil, to compete with it in price, would have to be purchased at between 6 and 9 cents if used at a strength of 20 per cent. Judging from the results of our experiments referred to above, it is more effective than single applications of either crude oil or kerosene at a strength of 20 per cent. It is apparently not prejudicial to the health of the dormant tree, as is oil if applied carelessly or under adverse conditions.

On the other hand the cost and trouble of preparation far exceeds that of the oil emulsion. The necessity of making the application while the mixture is yet warm, and its deterioration if allowed to stand longer than a few hours, are not in its favor. It also exerts a corroding influence upon copper and brass, and if much spraying is to be done with it specially made nozzles with hard-rubber apertures are necessary for its use. It should not be made up in brass kettles or used in brass pumps.

Strength Required.—Three strengths were used, the standard formula (30 pounds lime, 20 pounds of sulphur and 15 pounds of salt) being diluted to 40, 50 and 60 gallons. Very little if any difference in the results could be attributed to the use of the different strengths, and it is likely that the weakest will prove sufficiently strong.

Weather Conditions.—Applications were made at four different dates, viz.: February 28th, March 3d, 6th, and 7th. February 28th was a fair day, with a slight breeze from the southwest during the forenoon, freshening into a brisk wind in the afternoon, rendering thorough work difficult. On March 1st 1.33 inches of rain fell,

but the temperature (58° max. 33° min.) was cold for the season. On the 5th, .23 inch of rain fell, followed by two fair days and a slight rain (.02 inch) on the 8th. No more rain fell until the 14th, when it commenced and continued through the 16th, during which time the precipitation amounted to 4.75 inches.

RESIN WASH.

This wash has been long recommended as an effective remedy for some of the less resistant scales, and in a more dilute form as a summer treatment for Aphids and other soft-bodied sucking insects. One trial was made of it last winter, with poor results, and as it is more difficult to prepare than the lime, salt and sulphur it hardly seems worth further discussion here.

CRUDE CAUSTIC POTASH.

Crude caustic potash was used on four plots and at three different strengths, viz.: 5, 10 and 15 pounds to 50 gallons of water. The weakest solution proved very insufficient, but the two stronger ones were quite effective. Not even the strongest injured the trees in the slightest degree, so far as could be observed, its effect being rather to improve the appearance of the bark. It is, however, on account of its strong corrosive action very unpleasant to apply and detrimental to the hose; neither is it as effective as either the oil treatment, the soap washes or the lime, salt and sulphur. The results showed that not less than 10 pounds to 50 gallons should be used, and preferably 12 or 15.

CARBOLIC ACID EMULSION.

Crude carbolic acid in various forms was tried extensively and all strengths from 4 per cent. to 20 per cent. of emulsion mixed with water. The results were most unsatisfactory. Less than 15 per cent. of the emulsion, or one part to 6, did no appreciable execution amongst the scale. Stronger than this some effect was noticed, which became quite marked at 20 per cent. Even at this strength the carbolic acid was a little less effective than kerosene and more expensive.

PRACTICAL WORK WITH OILS IN A LARGE ORCHARD.

In addition to the regular experiments, an orchard of 55,000 three-year old peach-trees and 1,000 plums, belonging to Mr. W. C. Wright, of Fort Valley, Ga., was treated under our supervision. Mr. Wright was very much alarmed over the condition of his orchard, and he made a special request of the entomologist to assume full control of its treatment.

Beginning August 8th, 1901, the orchard was given a row-by-row inspection, which revealed 1,000 badly infested trees, well distributed. From these centers of infestation the scale had spread generally in all directions, leaving only a small per cent. of the trees entirely free. Beginning August 20th, all the badly infested trees that had been located were sprayed with a 10 per cent. strength of kerosene, using the Gould knapsack "kero-water" pump. This checked the breeding of the scale, and was apparently the means of saving a large number of trees that would otherwise have perished before time for winter treatment.

From December 25th to January 2d, each badly infested tree, with 15 or 20 adjacent, was sprayed with a 15 per cent. strength of kerosene, using the Gould barrel pump. In this manner the 1,000 trees representing the centers of infestation had received two applications of oil (10 per cent., followed by 15 per cent.) and about 15,000 trees one application, before the general treatment of the orchard commenced.

It was intended that the entire orchard should be treated with crude petroleum, but delay in obtaining this substance necessitated the continuation of the use of kerosene. Taking the trees in regular order, regardless of previous treatment, 17,000 were sprayed with a 20 per cent. strength of kerosene between January 3d and 23d. The crude oil had then arrived, and from January 25th to February 7th, 28,000 peaches and 1,000 plums were sprayed with a 20 per cent. strength of this substance, which registered 43½° gravity on the Baume oil scale. The remaining 10,000 trees being detached from the main orchard, and containing only a slight infestation of scale, were not taken into account in

PLATE I. SPRAYING IN THE WRIGHT ORCHARD, FORT VALLEY, GA.

making notes. However, they were sprayed with a 20 per cent. strength of kerosene, beginning February 11th. The effect of the treatment was carefully watched, and, at the end of three weeks, after 20 per cent. kerosene had been applied to the block of 17,000 trees in the general treatment, a small per cent. of live scale insects could here be found. It was then too early to make a definite determination of the results, but the owner was not satisfied with the indications, and late in February this block was given another application of kerosene at a strength of 15 per cent.

Reviewing the treatment, the orchard may be divided into plots which were sprayed as follows:

1. Consisting of a part of the 1,000 badly infested trees; 10 per cent. kerosene, followed by 15, 20 and 15 per cent. at various periods during the fall and winter.

2. Consisting of the remainder of the above mentioned trees; with 10 per cent. kerosene, followed by 15 per cent. kerosene and 20 per cent. crude oil.

3. Several thousand trees first sprayed with 15 per cent. kerosene, then later with 20 per cent. kerosene, and finally with 15 per cent. of the same substance.

4. The remainder of the trees first receiving the treatment of 15 per cent. kerosene, were sprayed later with 20 per cent. crude oil.

5. A large block sprayed with 20 per cent. kerosene in January and followed with 15 per cent. later.

6. The bulk of the orchard, which was treated only once, with 20 per cent. crude oil.

7. Several thousand trees upon which the application of 20 per cent. crude oil was followed by another of 15 per cent. of the same substance.

The entire work, throughout the season, was done in the most careful manner possible. Six Gould's barrel "kero-water" pumps were used, and these were supplied with oil by extra teams, while the water was piped into the orchard. The work was done with negro labor, superintended by the owner of the orchard and two intelligent white men, who at short intervals tested the percentage of oil discharges, and saw that every portion of the tree was moistened with the spray. When any part of the tree was found dry it was resprayed, even at the cost of turning

PLATE II. VIEW OF WRIGHT ORCHARD, FORT VALLEY. FROM THE SAME POSITION AS PLATE I. SHOWING TREES IN JUNE.

the team. By constant attention, the pumps were kept so adjusted as to do satisfactory work.

The results were most satisfactory When the winter work was begun the new double hose arrangement, by which the oil and water are kept separate until the nozzle is reached, was employed. Instead of producing a mechanical mixture, pure oil and pure water were alternately discharged. On one morning in trying to start five pumps with these attachments, a number of trees were sprayed with pure kerosene, resulting in the death of 40. The new style attachment was discarded, and no more injury was done, save, possibly, the death of about 50 other trees, which may be attributed to the combined effect of the scale and the treatment. The trees bloomed and leaved out normally, and bore a magnificent crop of fruit.

The scale was as nearly eradicated as we believe possible with any treatment. During the course of spring and summer, until June 17th, when the last observations were made, we visited the orchard three times, and carefully examined several hundred trees, both in the kerosene and crude oil blocks, and found only two trees bearing live scales. These were located in one of the kerosene blocks where two applications had been made. A general inspection of the orchard on June 17th, revealed no further infestation of living scales. It is understood, of course, that should every tree in the orchard be carefully examined a large number would, no doubt, show some infestation, but the observations have been sufficiently extensive to warrant the statement that better results can rarely be obtained with any practical treatment.

PREPARATION OF THE INSECTICIDES.

For the sake of convenience the formulæ and methods of preparing such substances as require special preparation were not given in connection with the discussion of the tests. Since the resin wash and carbolic acid emulsions did not give encouraging results, instruction for their preparation does not appear to be necessary here, and only the emulsion of petroleum oils and the lime, salt and sulphur wash, need be treated of at any length.

OIL EMULSION.

Preparation.—An emulsion of either crude petroleum or kerosene may be made from the following formula:

2 pounds potash whale oil-soap
4 gallons water
8 " oil

Weigh the soap carefully and place with the water in a vessel over the fire, using a slight excess of water to make up for evaporation. Fit a pump with a short piece of hose, to which is attached a nozzle for throwing a straight stream $\frac{3}{16}$ or $\frac{1}{4}$ inch in diameter. Pour the oil into the barrel or tub in which the pump is set, and when the whale-oil soap is dissolved and the solution begins to boil, add it to the oil and pump the whole vigorously back into itself for a period of at least ten minutes. The stream from the nozzle should be directed straight downward into the mixture so as to stir it to the very bottom. After a few minutes the oil and soap solution will be seen to combine, forming a thick, creamy emulsion, which when perfectly made will remain without change for weeks.

Materials and Pump Required.—Either crude oil or kerosene will give good results in making emulsion. The soap should preferably be some soft whale-oil soap, such as Good's No. 3. If a hard soap is used the emulsion will be curdy, and only with difficulty mix with water. Country lye soap answers admirably, but must be used in somewhat larger quantity than called for in the formula given above.

The ordinary Bordeaux spray pump answers very well for mixing the emulsion, but almost any pump will do that can be fitted with the requisite section of hose and nozzle. A "Bordeaux" or "Seneca" nozzle gives a very satisfactory sized stream for this work, though rather small.

The water used must be soft, for if hard no stable emulsion can be prepared, and it sometimes happens that foreign substances chancing to be present, will prevent the emulsification. If a lot of soap solution and oil, for any reason, fails to emulsify properly, the best thing to do is to throw the whole away, carefully clean up the pump, wash out all the vessels used and begin over.

Properties of the Emulsion.—The emulsion, if well made of the proper soap, will retain its creamy consistency when cold, and is easily mixed with water in all proportions. No alarm should be felt if a small portion of the soap and water fails to emulsify, and separates at the bottom, nor, if after being exposed to the air for some time, a thin scum forms over the surface. If on long standing globules of free oil rises to the surface, or if a thin ring of oil collects around the sides of the containing vessel, the emulsion should either be thrown away, or warmed up and agitated

afresh. It will keep in the concentrated condition, if well made, for weeks, or even months, but will quickly deteriorate if diluted.

Use of the Emulsion.—The emulsion will mix with water in any proportion, but unless kept constantly stirred will rise like cream to the surface. On this account, it is necessary that pumps in which it is used be furnished with an agitator, or else that the mixture be constantly stirred. In diluting the emulsion for use, if it has been made in quantity and allowed to stand, it should first be thoroughly stirred so as to become uniform throughout.

The following table shows the proper proportions of emulsion and water required to secure a given per cent. of oil:

3¾	gallons	emulsion	46¼	gallons	water	for	5	per	cent.	oil
7½	"	"	42½	"	"	"	10	"	"	"
11¼	"	"	38¾	"	"	"	15	"	"	"
15	"	"	35	"	"	"	20	"	"	"
18¾	"	"	31¼	"	"	"	25	"	"	"
22½	"	"	27½	"	"	"	30	"	"	"

If desired the emulsion may be prepared in small lots, each of which may be diluted to 50 gallons, and a given per cent. obtained. For instance, for a 50-gallon barrel full of the diluted emulsion the following amount of oil, soap and water would be necessary for the desired percentage:

For 25 per cent..	12½	gallons	oil,	6½	gallons	water,	3¼	lbs.	soap
" 20 " " ..	10	"	"	5	"	"	2½	"	"
" 15 " " ..	7½	"	"	4	"	"	2	"	"
" 10 " " ..	5	"	"	2½	"	"	1¼	"	"

Cost of Preparation.—The cost of preparation will, of course, depend upon the circumstances. With proper facilities, and the help of a boy 12, or even 16 gallons of oil may be emulsified at a time with a little extra trouble, and the work thus be carried on much faster. For each 50-gallon barrel of oil, 12½ pounds of soap will be required, which will vary somewhat in price, according to the market and freight charges. Fifty to sixty cents should cover it. With ordinary price for labor and soap, the cost per barrel for emulsifying oil should be between seventy and ninety cents.

LIME, SALT AND SULPHUR.

Preparation:

Quick lime	30 pounds
Salt	15 "
Flowers of sulphur	20 "
Water to make 60 gallons.	

Slake half the lime carefully and place it in a large kettle with 25 gallons of water; grind the sulphur up with a little water, breaking the lumps up as fine as possible and add to the lime; boil.

As it boils the liquid will gradually become thinner and thinner, the lime and sulphur dissolving simultaneously to form a deep orange red solution. When the sulphur has apparently all entered into solution, which may take two hours, or more, slake the remainder of the lime, add to it the salt, and pour the two into the lime and sulphur solution. Boil the whole for from half an hour to an hour longer, strain, and dilute with warm water to 60 gallons. Do not let it become thoroughly cold, but spray while yet warm.

The principal care in making up this wash, is to make sure that the sulphur is thoroughly dissolved. Flowers of sulphur are apt to be more or less lumpy, and these lumps are very difficult of solution. The more thoroughly the sulphur is ground up with water before being boiled with the lime, the less time it will take in boiling. Ordinarily two or three hours' constant boiling will be found necessary.

An iron kettle must be used if the boiling is done directly over a fire. A better and cheaper way, whenever a head of steam is available, is to place the sulphur, lime and salt together in a barrel half full of water, conduct the steam through a pipe to the bottom of the barrel, and boil for two or three hours, with occasional stirring, to make sure that nothing is settling. If a boiler is convenient, a pipe might be so arranged as to conduct steam to a number of barrels at once.

WHALE-OIL SOAP.

The only preparation required for the use of this substance is to thoroughly dissolve it in water by boiling. The boiling may be done in a large syrup kettle over a fire, or in a barrel into which steam is conducted. Measure the water, add to it the desired amount of soap, and stir until the solution is complete.

CRUDE CAUSTIC POTASH.

This substance needs only to be dissolved in water. No heat is required, but frequent stirring will hasten the solution.

RECOMMENDATIONS.

The results of our experiments do not materially change the former recommendations of this office for the treatment of the San Jose scale, but they broaden the field of effective remedies, giving the orchardist the option of choosing one of several. The petroleum oils (kerosene and crude petroleum), which have furnished the almost exclusive remedy for the scale in this State, came through the experi-

ments with more points in their favor than any other substance tested, although the lime, salt and sulphur wash gave almost equally as good results. In dealing with insecticides it is not usually safe to base recommendations upon one year's experience, and for this reason alone we are not willing to give the lime, salt and sulphur wash the endorsement that the results obtained from its use in the tests would warrant. However, it deserves to be recorded as very promising and given a place in the recommendations, allowing the orchard owners to choose between it and the oils. Results of further tests, which are planned for next winter, may place this wash upon an equal with oils, or even show its superiority to them.

It will be remembered that in all former recommendations issued from this office (Bulletin 1, and Circulars 4 and 5) two applications during the course of the winter have been insisted upon. One application appears to be sufficient for trees that have reached full growth, but the results of our experiments show most conclusively the necessity for two in the treatment of young orchards. The scale insects on young trees are more virulent, multiply much more rapidly and are afforded a better food supply than those on older trees, hence the number of surviving scales that would do no particular damage to old trees might seriously damage those not yet full grown. Moreover, it is quite impossible to reach every portion of a tree with one application, particularly if much wind is stirring, and it is usually advisable to make two even in case of old trees.

Concluding not only from the recent experiments but in part from practical results obtained by the growers, the recommendations for next winter's work stand as follows:

1. *Oil Emulsion.*—In November or early December apply a 15 per cent. strength of either crude oil or kerosene in emulsion with soap, and in February or early March (before the bloom buds open) repeat the application at a strength of 20 per cent. When obtained in car lots (as was done last winter) the crude oil is some cheaper and in general practice it has given slightly more satisfactory results in its effect upon both the scale and the trees, hence it should be given the preference. Not having yet completed the experiments with low grade crude oils we can recommend only the Pennsylvania product, registering not less than 43° gravity on the Beaume oil scale.

In spraying a tree the work should be done thoroughly but quickly, moistening every portion of the tree above the ground without allowing the substance to run down the trunk. Begin on the side of the tree opposite the pump and walk completely around, spraying from the top downward, and taking care to reach the twigs and the inside of the limbs. If even small spots or twigs are left the best results cannot be expected. On the other hand,

the use of an excess of oil will endanger the tree and should be carefully avoided.

2. *Oil in Mechanical Mixture.*—The mechanical mixture of either crude oil or kerosene, applied by the use of the oil-water pumps, may be substituted for the emulsion recommended above. So long as the pumps discharge a uniform percentage of oil, results equally as good as those obtained from emulsion may be expected. In addition to the precautions to be observed in the use of emulsion the mechanical mixing pumps require constant watching to keep them properly adjusted and the percentage of oil discharged should be frequently tested. To make these tests catch the mixture, as it is discharged from the nozzle, in a bottle with a straight side, allow it to stand until the oil rises to the top and then with a rule measure the volume of oil as compared with the volume of water beneath it. This will show the proportion of oil to water discharged. If the desired percentage is not obtained the pump should be looked into and readjusted.

3. *Lime-Salt-Sulphur Wash.*—The lime, salt and sulphur wash applied in February or March, before the trees bloom. This remedy gave such promising results in the tests that we venture to include it in the recommendations, feeling confident of its success when properly prepared and thoroughly applied. The instructions for its preparation should be carefully observed, with particular reference to the boiling, and its application should be thorough.

Since no fall or mid-winter applications of this wash were made in the experiments we can at present advise its use only for spring spraying.

4. *Whale-Oil Soap.*—In the treatment of family orchards it may be found more convenient to use whale-oil soap than the other more complicated remedies. Use a potash soap and dissolve it (by boiling) in water at the rate of 2 lbs. to each gallon. Make the application in the early spring just before vegetation begins, using a spray or cloth mop, preferably the former. Should only a very small number of trees be involved, they might be successfully treated by rubbing on the solution with a cloth, provided great care be taken to coat the small twigs as well as the trunk and limbs.

More thorough execution to the scale would be expected from two applications, one at a strength of 1½ lbs. to the gallon of water and the other as recommended above. A single application will not ordinarily give entire satisfaction.

Crude caustic potash being cheaper, although not so effective, may in some cases be advantageously substituted for whale-oil soap; and indeed, in commercial orchards where the scale is in a weakened condition from the age of the trees this substance may be used with success. For effective work a strength of at least 10 lbs. to 50 gallons of water will ordinarily be required.

Bulletin No. 6 January 15, 1903

THE LEAF CURL DISEASE

OF THE

PEACH

AND ITS

TREATMENT

BY

W. M. SCOTT, STATE ENTOMOLOGIST

GEORGIA STATE BOARD OF ENTOMOLOGY

ATLANTA, GA.

Geo. W. Harrison, State Printer, The Franklin Printing and Pub'ishing Co., Atlanta

The Leaf Curl Disease

OF THE

Peach and its Treatment

BY W. M. SCOTT, STATE ENTOMOLOGIST.

Peach Leaf Curl is a disease which appears in our orchards in early spring, causing the young and tender foliage to thicken, curl and finally drop. (See Fig. 1.) Although it may occasionally be seen on the twigs, its attacks are confined principally to the leaves.

In the early part of the summer all the affected leaves are shed and nothing more is seen of the disease until the following spring. When an orchard is but slightly affected, a new crop of leaves is quickly produced and the damage is slight; but when, as frequently happens, the greater part of the foliage is involved the vigor of the tree is impaired, the present crop of fruit destroyed and future crops affected.

DISTRIBUTION.

The Leaf Curl disease is widely spead over the entire world wherever the culture of the peach is attempted, although its introduction into some of the newer countries, as Australia and New Zealand, appears to have been accomplished within quite recent years. In the United States it is more serious in the northern and western portions, and less so in the extreme south and along the Atlantic seaboard. In Georgia it is confined almost entirely to the northern half of the State, very rarely occurring to an injurious extent in the southern and middle portions. The principal exceptions are cases of young orchards planted with

FIG. 1—Two peach twigs showing leaves badly diseased with Leaf Curl. (*Photo by the author.*)

nursery stock brought from infested sections, which during the first season develop the disease to a considerable extent, but not thereafter. In some sections of North Georgia the disease exists in its worst form, not infrequently causing the loss of the entire crop of some varieties in individual orchards.

NATURE OF THE DISEASE.

The curling and subsequent loss of the leaves is due to the growth of a fungus, a minute microscopic plant, which consists of a network of fine thread-like stems (Figure 3)

FIG. 2—Spores or fruit of the Leaf Curl fungus, greatly enlarged (after Pierce).

permeating and subsisting upon the substance of the young leaves, much as the roots of the peach-tree itself traverse the soil and draw from it nourishment for the tree. This parasitic plant lives on the juices of the leaf, causing by its presence the well-

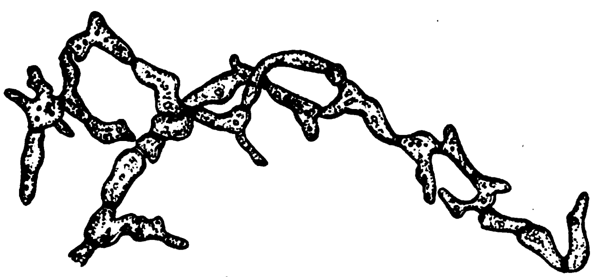

FIG. 3—The mycelium or vegetative parts of the Leaf Curl fungus, greatly enlarged (after Pierce).

known distorted appearance; and later tiny branches push through the surface of the leaf, bearing upon their extremities the spores or fruit of the fungus (Figure 2.) These spores are often produced

in such numbers as to give the leaf a dusty appearance, as though covered with a fine bloom. This dust-like substance, which will rub off when touched with the finger, contains the spores in countless millions. Scattered by the wind they become lodged in the microscopic crevices of the bark and scales of the young buds; and the following spring germinate like seeds, the young fungous plant sending its branches into the tender foliage and causing a reappearance of the trouble of the previous season.

Although Leaf Curl can not be produced without these spores any more than a crop of cotton without seed, the common belief that the disease is due to cold weather and rain in the spring is not without good foundation. Just as any kind of seed will sprout quicker when the soil and conditions are right, and perhaps under adverse circumstances refuse to grow at all, just so will the spores of the Leaf Curl fungus germinate more readily when the conditions are favorable; that is, during a long continued spell of cloudy or rainy weather, or just after the young peach leaves have been subjected to an unusual degree of sudden cold. The first mentioned condition favors to the highest degree the development of the spores and the second renders the tender foliage weaker, less able to resist the entrance of the sprouting spores, while offering at the same time better conditions of growth. It is a fact frequently noted that the Leaf Curl is worse on the exposed portions of an orchard, as upon a northern slope where the trees are less protected from the colder winds, and this is exactly as would be expected from the nature of the disease. In these situations the expanding leaves are bruised and weakened by the wind and cold, and thus rendered especially liable to the attacks of the parasite.

TREATMENT.

Summer Treatment.—After the first external signs of the Leaf Curl disease appear in the spring, nothing can be done to check its ravages for that season, and the extent of the damage will depend entirely upon the weather conditions, as they may prove favorable

or otherwise to the growth of the fungus. It is always recommended, however, that the orchard be given an extra amount of cultivation as soon as it is seen that a serious amount of foliage is about to become involved. An application of nitrate of soda worked into the soil will also greatly assist the trees in producing a new crop of leaves. By such treatment the present crop of fruit may perhaps be saved, the trees strengthened and put in a condition favorable for the development of buds for the following crop,. and in very bad cases, the life of the tree even, might otherwise be in danger. This treatment is merely to meet the emergency, however, and should always be followed by spraying the following winter.

Prevention by Spraying.—Few fungous diseases affecting cultivated plants have proven more easily or surely prevented than the Leaf Curl of the peach. It has been demonstrated beyond question that even the worst infected orchards may, by proper spraying at the right season, be practically freed of the pest, and with a single application of the treatment. Numerous fungicides have been used and recommended, but of them all the safest and most effective has proven to be the Bordeaux mixture. This should be applied in late winter or early spring. After the buds have become swollen the germs of the fungus begin to penetrate the tissues and the treatment is therefore less effective, so that it is necessary to begin spraying in time to finish at least two weeks before the trees are likely to bloom. A little later when the young leaves have begun to push out and the evidences of the disease become apparent, it is altogether too late, and a spraying, so far as the Leaf Curl is concerned, would be a waste of labor and material.

It is very important in spraying for this disease that every part of the tree be reached by the Bordeaux or other mixture used, for if a limb or a portion of a limb be missed the fungus will develop upon it, and thus tend to reinfect to some degree the rest of the tree. Advantage should always be taken of the wind, if it chances to be blowing. If the man holding the nozzle stand first on one side of the tree and then on the other, directing the spray upon the branches but diagonally against the wind,, the finer particles

will be blown back, wetting the other side of the branches and passing to one side of the operator. On a perfectly calm day the operator should stand still on one side of the tree and cover each limb in order, then pass around to the exactly opposite side and repeat the operation with equal care. In all cases the nozzle should be held below rather than above the part of the tree being treated and the spray, thus directed upward, will, in falling, wet the upper side of the horizontal branches.

SUBSTITUTES FOR BORDEAUX.—The bluestone solution without the addition of lime has been recommended and is used quite extensively in some parts of the North. Although it has been tried and proven to be effective in Georgia, the addition of the lime is still recommended for our conditions, as it certainly adds to the effectiveness and safty of the operation. If it is desired to use the bluestone alone, only two pounds to fifty gallons of water can be employed, as a greater strength endangers the fruit buds.

Washes containing lime and sulphur as the active ingredients have been used for some time in fighting the San Jose scale on the Pacific coast, and from present appearances are about to prove equally effective against this insect in the East. Nearly twenty years ago it was noted on the trees thus treated in California that the Leaf Curl was prevented to a certain extent, and subsequent experiments under the auspices of the United States Department of Agriculture showed conclusively the value of this preparation as a partial preventive, but that it was not so effective as the Bordeaux mixture.* The substitution of four or five pounds of bluestone for the fifteen pounds of salt called for by the regular formula has been found to add to the effectiveness of the mixture against the Leaf Curl without detracting from its value as an insecticide, and though this spray has not been tested in Georgia, it will no doubt prove of great value when scale insects as well as fungous diseases are to be fought.

PREPARATION OF BORDEAUX MIXTURE.—Bordeaux mixture is perhaps more widely known and used as a fugicide than all other

* Full directions for preparing the lime and sulphur wash are given in Bulletin No. 5 of this office.

substances together, and on that account it is thought advisable to go into some detail in the directions for its preparation. It is composed of a mixture of the dilute solutions of lime and bluestone, and for the treatment of Leaf Curl the proportions are as follows:

5 pounds fresh, unslaked lime,
5 pounds bluestone (sulphate of copper),
50 gallons water.

As much as six pounds of bluestone and an equal quantity of lime may be employed with safety, and in some cases advantageously. However, when it is desired to use Bordeaux for brown rot or other diseases after the foliage is out, the quantity of bluestone should be reduced to three pounds and that of the lime increased to nine pounds, because of the injurious effect that strong Bordeaux has upon peach foliage.

Slake the lime carefully with just enough water to reduce it to the consistency of thick cream and dilute to 25 gallons; dissolve the bluestone in 25 gallons of water also. Then in a separate barrel mix the two solutions, first pouring in a bucket of one and then a bucket of the other, or better still, pouring them in simultaneously. After thoroughly stirring the mixture and allowing it to stand for a few moments it will be ready to spray.

When thus prepared Bordeaux is at its best, consisting of a fine, flocculent, pale blue precipitate suspended in the water. If either or both of the ingredients should be in concentrated solution when the mixing is done, the resulting Bordeaux is coarser grained, settles much more quickly and is less effective as a spray. Even the best will begin to settle quickly on standing, and it is esential that the spray pump be supplied with the an agitator that will keep it stirred in the act of pumping.

The bluestone may be gotten into solution most quickly and readily by suspending it in the corner of a fertilizer sack just below the surface of the water, or by the use of a small quantity of hot water.

When a considerable amount of spraying is to be done it will be found convenient to prepare *stock solutions*, by dissolving 25 or 50 pounds of bluestone in an equal number of gallons of water, while a like amount of lime is slaked and diluted to a similar volume. Then by dipping out five gallons of either solution it will be seen that an equal number of pounds of bluestone or lime will be secured, and the separate weighing and dissolving of the small lots avoided. The two ingredients should never be mixed unless diluted as before described.

Another point that must be kept in mind is that the bluestone solution, and the finished Bordeaux to a less extent as well, exert a corrosive action on iron and should not be used in all iron pumps, nor contained in iron or tin vessels.

It is a general precaution that ought to be observed in all spraying operations, that everything going into the spray pump barrel should pass through a strainer, and this is particularly necessary in the case of mixtures containing lime. A very god home-made strainer may be made from a strong wooden bucket by boring an auger-hole in the bottom and inserting a six inch piece of iron piping. A piece of wire gauze, preferably of brass or of copper, is then tacked over the top of the bucket; a most commodious and effective strainer and funnel combined is thus obtained.

In extensive operations, and especially where water-works are available, it is often found convenient to carry on the preparation of the Bordeaux upon a platform, equal or exceeding in height that of a wagon. The transference of the finished mixture to the pump barrel as it stands in the wagon is thus made easier, or the arrangement may be such as to effect the transfer by means of gravity.

RESULTS FOLLOWING THE USE OF BORDEAUX IN GEORGIA.

In the spring of 1900 an experiment to determine the effect of spraying for the Leaf Curl was conducted in the orchard of Judge Geo. F. Gober at Marietta, Georgia, and the results were such as to lead to the unhesitating recommendation of Bordeaux as a pre-

ventive of the disease. The results of the treatment of numerous orchards in north Georgia the following season were somewhat conflicting, however, and many growers became skeptical as to the value of the treatment. Another experiment was accordingly thought advisable and arrangements were made with Mr. S. R. Cockrill of Rome for conducting the work in his orchard last spring.

The results of this experiment showed:—

1. That Bordeaux as recommended, applied two to three weeks before the blooming period would prevent the Leaf Curl almost absolutely.

2. That one application is usually sufficient, but that if it were followed within a few days by rain, a second application might be necessary to secure the best results.

3. That it is too late to spray with good results after the buds begin to open, although a partial prevention of the disease can be secured by an application at this time.

A more detailed account of these experiments need not be given here, but it will perhaps not be out of place to quote the results of a few orchardists who have used the treatment and found it all that was expected. Among the most interesting that have as yet been called to our notice were those obtained by Mr. T. J. Madden, who owns a considerable orchard near Rome. In recounting his experience before the meeting of the North Georgia Fruit Growers' Association at Adairsville on May 30, 1902, Mr. Madden said:

"In the spring before the trees bloomed I commenced spraying with the usual Bordeaux mixture. Before completing the task I decided to try an experiment on my own hook by using double strength mixture. Before I could finish spraying all the trees the buds had opened so much that it was too late to finish, so we left a few rows unsprayed. Now for the result:—The unsprayed rows had Leaf Curl very badly, and absolutely no peaches; the trees sprayed with the usual strength of Bordeaux mixture have a fair crop of peaches, and practically no curl. The trees sprayed with the double strength mixture have a fine crop, at least double the amount of fruit over the ordinary spraying, and no Leaf Curl."

These results, the statement of which was substantiated by several witnesses, are very remarkable, and the increase in the amount of fruit on the trees sprayed with the double strength mixture just before the opening of the buds, was probably due to the fact that a large portion of the fruit throughout the State was killed in the bloom last season by the brown rot fungus. Our experiments showed that this trouble was only slightly affected by the ordinary strength of Bordeaux, but it may have yielded to that used by Mr. Madden.

At the same meeting, Mr. J. H. Brownlee, one of the most prominent growers of Plainville, Ga., said in the course of his remarks:

"Last year I had a young orchard that had the Leaf Curl very bad, and I though that I would save it this year. We went over the whole orchard (with the Bordeaux treatment) and finished all but one row, and I told the boys that we would leave that row. The result was that while the rest of the orchard did not have it at all, that one row had it very badly, and not only lost all its leaves, but its fruit."

TREATMENT OF NURSERY STOCK.

Leaf Curl quite often occurs on young trees during the first seasons' growth, and as a preventive against loss from this source it is recommended that nursery stock coming from a section where the disease prevails, be dipped, before planting, in a large barrel or vat containing Borbeaux mixture. If care be taken not to wet the roots there is no danger whatever in this process, and it will be especially successful when done in the spring. By carefully disinfecting the stock in this manner, an isolated orchard might remain unaffected for some years, even in a section where the natural conditions are favorable to the development of this disease.

GEORGIA

State Board of Entomology

BULLETIN No. 8. October, 1903

Treatment of Orchards Infested with San Jose Scale

BY

WILMON NEWELL

CAPITOL BUILDING . . . : : ***Atlanta, Ga.***

ATLANTA, GA.
GEO. W. HARRISON, STATE PRINTER
1903

Georgia State Board of Entomology.

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DUDLEY M. HUGHES, Pres. of State Agricultural Society, Danville.

WILMON NEWELL, State Entomologist and Sec. of the Board, Atlanta.

R. I. SMITH, ... Assistant State Entomologist, Atlanta.

LETTER OF TRANSMISSION.

To the Honorable Board of Entomology of the State of Georgia :

SIRS:—I beg to submit the accompanying manuscript for publication and distribution in accordance with an Act of the General Assembly of Georgia approved December 20, 1898.

The principal matter consists of the results of experiments instituted against the San Jose scale by my illustrious predecessor, W. M. Scott. The results obtained have been such as to demonstrate the value of the lime-sulphur-salt wash as a remedy for this dreaded pest, and no doubts now remain as to the superiority of this treatment as compared to the treatment with oils, which latter has heretofore been in general use. That the San Jose scale can be successfully controlled is fully established, and the fruit growers of Georgia are to be congratulated that they now have available a cheap, safe and highly satisfactory method whereby serious damage from this insect may be prevented.

Very respectfully,

WILMON NEWELL,
State Entomologist.

ATLANTA, GA., Oct. 15, 1903.

Approved :

O. B. STEVENS,
Chairman of the Georgia State Board of Entomology.

ATLANTA, GA., Oct. 15, 1903.

TREATMENT OF ORCHARDS INFESTED WITH SAN JOSE SCALE.

WILMON NEWELL, STATE ENTOMOLOGIST.

Bulletin No. 4 of the Georgia State Board of Entomology, issued in September, 1902, and Bulletin No. 5, issued in November, 1902, by Prof. W. M. Scott, former State Entomologist, give full and practical instructions for treating scale-infested orchards. A number of experiments have been conducted by this office since the publication of the above and the results have been such that it seems advisable to place them before the fruit-growers in the present bulletin.

The development of successful methods of controlling the San Jose Scale has been rapid, but not until recently has full and satisfactory control been possible. When the Georgia State Board of Entomology was established in 1898, the occurrence of San Jose Scale in a commercial orchard was commonly considered as meaning total destruction, and several owners of infested orchards had even given up all hope and had allowed their trees to succumb to this dreaded pest. The undertaking before Prof. Scott was a most formidable one, but through the ready support and co-operation of the State Board of Entomology, as well as the hearty assistance given by the horticulturists of the State, he was enabled to bring to the aid of the orchardists all known methods of fighting the San Jose Scale, as well as the results obtained by experiments in various parts of the United States. In addition to this, Prof. Scott carried on extensive experiments each year, looking to the improvement of methods and the possible introduction of new and better measures. His efforts in this line have been attended by marked success and the progress made by Georgia in successfully controlling the San Jose Scale, has not been exceeded by any other State. Indeed, we feel safe in saying that to-day the commercial orchardists of Georgia are better equipped for, and more thoroughly understand, controlling this dreaded pest than those of any State in the Union.

The various materials, washes, and "patent" compounds that have promised to prove at all successful have been tested in Georgia. Of all the substances, however, none have proved at all satisfactory under Georgia conditions except the oil treatments, and the lime-sulphur-salt wash.

WINTER TREATMENT.

OILS.

The use of oils, both kerosene and crude petroleum, has been extensive in Georgia orchards. The results upon the whole have been highly satisfactory, and the efficiency of the oil in killing San Jose Scale can not be doubted. While a few isolated cases of injury to the trees have occurred, they are in most cases traceable to defective spraying machinery or to carelessness on the part of the negro laborers employed. The oils have been applied with "mechanical mixture" pumps or in the form of emulsions with soap. The latter has proved the most satisfactory, and we have heard of but one case of injury to trees where the emulsion was used. Even in this case, the evidence indicates that the mixture was not properly emulsified by powerful agitation and hence a perfect emulsion was not obtained.

The mechanical mixture pumps referred to consist essentially of two separate tanks for containing the oil and water, a separate pump for each, and mechanical devices whereby the flow of each can be regulated to secure the percentage of oil desired. During the past few years, the writer has made careful tests of several such pumps, manufactured by different firms. In no case have we found a pump which can be depended upon to maintain even approximately a given percentage. In one experiment a new pump direct from the factory and pronounced by the makers as being in perfect condition, was kept constantly running for one hour. The levers and pumps were set to throw a mixture of 15 per cent. oil and 85 per cent. water. Tests made during the hour showed that the percentage of oil varied from 10 to 82 1-2 per cent. Such pumps can not be depended upon, especially as any slight derangement or clogging is most certain to result in the percentage varying to a dangerous degree or in stopping the flow of either the oil or water. Undiluted oil sprayed upon a peach tree is almost certain to kill the tree, while pure water is useless so far as the scale insects are concerned.

Where intelligent white labor is available, and the pumps are kept in order and frequently tested to see that the percentage is fairly constant, the mechanical mixture pumps can be effectively used. Indeed, large commercial orchards have been sprayed with these pumps without a single tree being injured. Where negro help is used, however, the risk is greater. The laborers are prone to stop the pump long enough for the oil and water in the hose to separate. They also exercise less intelligence and judgment in keeping pumps in order and properly adjusted. It is likewise almost impossible for a foreman to keep several pumps under constant supervision and keep all properly adjusted. To the orchardist who has successfully controlled the scale by using the mechanical mixtures of oil and water, without injury to his trees, we do not recommend the adoption of other measures. However, we can not unqualifiedly sanction the use of "mechanical mixture" pumps.

At the time of publishing Bulletins Nos. 4 and 5 of this office, no more efficient agency than that of the oils was known. The lime-sulphur-salt wash had not at that time been sufficiently tested to warrant its full recommendation for Georgia conditions. While some slight injury to trees has occurred through the use of oils—in most cases through defective machinery or work; in other cases perhaps through circumstances not wholly under the control of the orchardist—the owner of infested orchards may well compare the slight damage done with the inevitably heavy damage that would have resulted from the scale had not the treatment been adopted.

Prof. Scott's experiments have shown that a strength of less than 20 per cent. of oil, with water, is not effective against the San Jose Scale. Experiments carried out by the writer in the peach belt of northern Ohio in 1900-01 gave similar results, and also showed that a percentage of 35 per cent. or over of oil resulted in injury to the trees, even when perfectly dormant. For *all* conditions the safe percentage is probably as low as 25, and hence we are confined to very narrow limits, i. e., the use of oil (either crude oil or kerosene) at a strength varying between 20 and 25 per cent. Experiments have been conducted by this office, in which oils and the lime-sulphur-salt wash were used side by side on infested trees. The comparative results are given below in the paragraph treating upon the latter preparation.

OIL EMULSIONS.

Where it is deemed advisable to use any of the oils, they are most safely applied in the form of emulsions. For the preparation of the emulsion, we can do no better than to give the directions published by Prof. W. M. Scott in Bulletin No. 5, which are as follows:

"*Formula and Directions.*—An emulsion of either crude petroleum or kerosene may be made according to the following formula:

"2 pounds potash whale-oil soap.
"4 gallons water.
"8 gallons oil.

"Weigh the soap carefully and place with the water in a vessel over the fire, using a slight excess of water to make up for evaporation. Fit a pump with a short piece of hose, to which is attached a nozzle for throwing a straight stream 3-16 to 1-4 inch in diameter. Pour the oil into the barrel or tub in which the pump is set—*away from the fire*—and when the whale-oil soap is dissolved and the solution begins to boil, add it to the oil and *pump the whole vigorously back into itself for a period of at least ten minutes.* The stream from the nozzle should be directed straight downward into the mixture so as to stir it to the very bottom. After a few minutes the oil and soap solution will be seen to combine, forming a thick, creamy emulsion, which when perfectly made will remain without change for weeks.

"For a 20 per cent. strength add water to make 40 gallons.

"For a 15 per cent. strength add water to make 53 1-3 gallons.

"For a 10 per cent. strength add water to make 80 gallons.

"*Materials and Pump Required.*—Either crude oil or kerosene will give good results in making emulsion. The soap should preferably be some soft whale-oil soap, such as Good's No. 3. If a hard soap is used the emulsion will be curdy, and only with difficulty mix with water.

"The ordinary Bordeaux spray pump answers very well for mixing the emulsion, but almost any pump will do that can be fitted with the requisite section of hose and nozzle. A 'Bordeaux' or 'Seneca' nozzle gives a very satisfactory sized stream for this work, though rather small.

"The water used must be soft, for if hard no stable emulsion can be prepared, and it sometimes happens that foreign substances chancing to be present will prevent the emulsification. In case limestone or hard water is to be em-

ployed, it should be broken by the addition of a small quantity of lye. If a lot of soap solution and oil, for any reason, fails to emulsify properly, the best thing to do is to throw the whole away, carefully clean up the pump, wash out all the vessels used and begin over.

"*Properties of the Emulsion.*—The emulsion, if well made of the proper soap, will retain its creamy consistency when cold, and is easily mixed with water in all proportions. No alarm should be felt if a small portion of the soap and water fails to emulsify, and separates at the bottom, or, if after being exposed to the air for some time, a thin scum forms over the surface. If on long standing globules of free oil rise to the surface, or if a thin ring of oil collects around the sides of the containing vessel, the emulsion should either be thrown away, or warmed up and agitated afresh.

"When diluted the emulsion may slowly rise, like cream, to the surface, and in order to prevent this the spray pump in which it is to be used should be provided with an agitator."

As stated above, we do not consider the oil treatment nearly so effectual as the lime-sulphur-salt, but where oils are used, we consider the 20 per cent. emulsion the best form for winter treatment.

THE LIME-SULPHUR-SALT WASH.

As the San Jose Scale first appeared in the United States upon the Pacific coast, various remedies were tried by Oregon and California fruit-growers. Their experience developed the fact that for California conditions the lime-sulphur-salt wash gave excellent results. Upon the appearance of the scale in the East, this same wash, as well as others, was tested under eastern conditions. An experiment with the lime-sulphur-salt wash was conducted by Prof. C. L. Marlatt, of the United States Department of Agriculture, in 1894, but the results were reported as extremely unfavorable.*

Prof. Marlatt's negative report evidently had the effect of discouraging further experiments along this line by entomologists, it being taken for granted that the wash could not be successful under climatic conditions prevailing in the South and East. Accordingly attention was directed mainly to the various oils and soaps in the hope of securing a satisfactory treatment.

In 1900 Prof. Marlatt again conducted experiments with the lime-sulphur-salt wash,† and in this case exceptionally good results were obtained. In 1901 Prof. S. A. Forbes un-

*Bul. No. 3, n. series, U. S. Div. of Ent., pp. 61 and 71.
†Bul. No. 30, n. series, U.S. Div. of Ent., pp. 34-37.

dertook detailed experiments with this wash in Illinois and secured excellent results.*

In the winter of 1901-02 the writer carried out experiments with this same wash in Ohio under the direction of Prof. F. M. Webster, and the results obtained compared favorably with those obtained by using whale-oil soap and the kerosene treatments then in extensive use in Ohio peach orchards.

So far as we are able to determine the first extensive use of the lime-sulphur-salt wash in the East was by Mr. E. C. Green, who, during the winter of 1901-02 employed this preparation almost exclusively in treating scale-infested peach orchards in Illinois, under the direction of Prof. S. A. Forbes, State Entomologist.

At about this time Prof. W. M. Scott commenced experimenting with this wash in Georgia. The unfavorable report made by Prof. Marlatt in 1894 caused entomologists to "go slow" in using and recommending this insecticide, and Prof. Scott, with his usual precaution, first tested it in a small way. His experiments of 1901-1902 gave promise of the wash being successful under Georgia conditions.† In the winter of 1902-03 the lime-sulphur-salt wash was tested much more extensively by Prof. Scott, and was also used by the owners of several large commercial orchards. The results of these treatments were given by Prof. Scott in his address before the Georgia State Horticultural Society at Athens, Ga., August 3 and 4, 1903, and will appear in the Proceedings of that Society. A brief mention of the results obtained will not, however, be out of place in the present connection.

In February, 1903, the Ohio Fruit Land Co.'s orchard at Myrtle, Ga., was sprayed with the regular strength of lime-sulphur-salt wash under direction of the Manager, Mr. C. W. Withoft. All trees were thoroughly coated, and after the spraying was finished Prof. W. M. Scott selected a number of badly infested trees for continued careful observation. No extra pains were taken in treating these trees, hence they furnish a reliable indication of the efficiency of this treatment as generally carried out. The trees selected for study were all heavily incrusted with San Jose Scale, and the most of them were in such bad condition that their recovery was not expected. The trees have been examined from time to time during the present season, and the results of the examination are given in the following Table:

*Bul. No. 71, Ill. Agr. Exp. Station.
†Bul. No. 4, Ga. State Board of Entomology, pp. 20-21.

TABLE I.

Effect of the Lime-Sulphur-Salt Wash upon Trees Heavily Incrusted with San Jose Scale.

Tree No.	Treatment.	Condition when Sprayed.	Date Examined.	Per cent of Live Scale.	Larvæ found.	Condition of Tree at Date of Examination.
1	Lime-sulphur salt wash in Feb., '03.	Incrusted.	April 20, '03 [1]	20	0	
"	"	"	June 17, '03 [2]	4	0	Scales sluffing from bark, new healthy bark forming beneath scales.
"	"	"	Aug. 7, '03 [2]	Trace [3]	0 [4]	Luxuriant growth. Bark clean and bright. Very few old scales still adhering to bark.
2	"	"	April 20, '03	22	0	
"	"	"	June 17, '03	8	0	Same condition as tree No. 1.
"	"	"	Aug. 7, '03	—— [5]	Scattering.	" " "
3	"	Incrusted and nearly dead at time of treatment	June 17, '03	4	0	Tree fully recovered and making a vigorous growth.
4 [6]	"	Incrusted. Had put out "water sprouts."	June 17, '03.	2 [7]	0	

TABLE I—*Continued.*

Effect of the Lime-Sulphur-Salt Wash upon Trees Heavily Incrusted with San Jose Scale.

Tree No.	Treatment.	Condition when Sprayed.	Date Examined.	Per cent. of Live Scale.	Larvæ found.	Condition of Tree at Date of Examination.
(9) 5	"	Incrusted.	June 17, '03	5	0 (8)	Growing well.
(11) 6	"	"	June 17, '03	3	0	" "
"	"	"	Aug. 7, '03	—— (10)	Trace	Vigorous growth.
7	"	Incrusted and considered past all chance of recov'ry	June 17, '03	4	5 crawling larvæ found on entire tree	Putting out well.
"	"	"	Aug. 7, '03	——	About 1 immature scale per twig.	Healthy, vigorous growth.

(1) From notes by Prof. W. M. Scott.
(2) Examination by Scott and Newell.
(3) By "trace" meaning that a careful examination of from five to fifteen minutes was required to find a living scale.
(4) Found a few half-grown female scales most of which had recently died. On entire tree found but 3 live scales.
(5) At this date, found 2 adult and 4 partially grown females on trunk of this tree, and an average of 1 immature scale on each young shoot.
(6) Trees 1, 2, 3 and 4 are all of the variety Belle (Syn=Belle of Georgia.)
(7) Examination showed large numbers of adult females—brown and discolored, but not yet dried out—that had but recently died.
(8) At this date many adult females had but recently died. Under a number of adult female scales were found living larvæ, but none could be found crawling about or established upon the bark or twigs.
(9) Variety, Early River.
(10) On Aug. 7, found one adult female with larvæ underneath scale, and 6 immature females. Many scales of this year's breeding had established themselves on treated portions of the bark, but had recently died.
(11) Variety, Early River.

From the above results it will be noted that several very interesting points are brought to light.

First, the lime-sulphur-salt is not immediately destructive to the adult insects, but for a considerable time *does* prevent the larvae from establishing themselves on the treated portions.

Second, that the wash slowly corrodes the scaly covering, ultimately exposing the mature insect to the action of the weather and offering ready access to predaceous enemies.

Third, that after much of the material has been washed from the trees, the larvæ can establish themselves and grow for some little time, but that sufficient material evidently remains to eventually kill the great majority of them. The death of larvæ in considerable numbers was noticed on several of the above trees as much as five months after treatment. An insecticide which exerts a continuous action for several months is obviously more desirable than one which, even though more powerful, is effective for a few days only.

Experiments with the lime-sulphur-salt were conducted in a number of other orchards by Prof. Scott, and orchards treated independently by the owners were also kept under supervision during the summer. In all of them the same gratifying results were secured.

In no case was there any indication of injury to the trees, except where the wash was applied after the buds began to open. In such cases the fruit buds—and in some instances the twigs—were killed back, thereby decreasing the fruit crop. In the orchard of Mr. S. H. Rumph at Marshallville, Ga., three plots, each containing Belles and Elbertas, were used in a comparative experiment. Plot 1 was sprayed in February with an oil emulsion containing 20 per cent. of oil. Plot 2 was sprayed in December with the lime-sulphur-salt. Plot 3 was given the same treatment as No. 2, and in addition, was sprayed again with the lime-sulphur-salt wash in early March, just before the buds opened. Space can not be taken here to give the results of the various examinations, but, briefly stated, the trees sprayed with lime-sulphur-salt wash in December have had as little scale upon them this summer as have the trees sprayed with oil emulsion in February. The double treatment, i. e., spraying with lime-sulphur-salt in December and again in early March, was far more effective than either the December treatment alone, or the oil emulsion treatment in February.

The orchard of Mr. J. D. Hendrickson at Lee Pope, Ga.,

was sprayed by the manager, Mr. C. G. McCarty, under the direction of this Department, with 15 per cent. of oil, using a mechanical mixture pump. This treatment was followed about two weeks later by a thorough spraying with lime-sulphur-salt. About 50,000 trees were given this treatment and not more than five or six trees were in any way injured. These injured trees, we were informed by Mr. McCarty, were given *several* applications of the oil mixture. Our earlier examinations of this orchard the present season failed to reveal a single living scale, even on trees previously incrusted, thus showing that the treatment had been thorough and effective. When the writer last examined this orchard on September 8, 1903, only a very few living scales could be found.

From the experience of the past year we must conclude that the lime-sulphur-salt wash is more effective than the various emulsions and mixtures of oils, and that it is safer. The advantages and disadvantages of the two may be compared as follows:

OILS	LIME-SULPHUR-SALT
Complicated mechanical mixture pumps must be used, or the oil made into an emulsion.	Simply constructed and powerful pumps can be used.
"Mechanical mixture" pumps readily get "out of order"	"Single" or simpler pumps are less likely to get out of order and breaks are more quickly noticed.
The oil and water mixture requires constant testing to see that the percentage of oil does not exceed the limit of safety.	No testing of percentage is necessary.
When the pumps are stopped for any length of time, the oil and water in the hose will separate and either pure oil or pure water will be thrown when the pump is again started.	The lime-sulphur-salt mixture is homogeneous, hence does not separate materially upon standing.
The necessity of frequently being compelled to send to distant points for oil, and often consequent delay of treatment at proper time.	Composed of common materials obtainable in almost every town and village in the State.

MAKING THE LIME-SULPHUR-SALT.

The standard formula, which was used in the experiments cited above, is as follows:

Lime (unslacked)	30 lbs.
Sulphur	20 lbs.
Salt	15 lbs.
Water	60 gals.

We have been most successful in making this mixture according to the following plan: Place about one-fourth of the water in an *iron* kettle and bring to a boil. When the boiling point is reached add the unslaked lime, and during the consequent violent boiling add the sulphur (which should previously have been mixed with water), and keep well stirred. A few minutes later add the salt and continue the boiling for two hours. Water may have to be added from time to time to make up for evaporation—sufficient water should be kept in the kettle to prevent "burning," but more than this is not desirable. At the end of the two hours add water to make 60 gallons and strain through a fine mesh iron strainer into the tank of spray pump. Apply while still hot.

This wash has a marked corrosive action upon brass and copper, and so far as possible iron should be used in handling it and in the pumps. Brass and copper pumps can, however, be used with a minimum amount of corroding if they be thoroughly washed out with clear water after each day's spraying.

In applying this wash the trees should be thoroughly coated, using "Vermorel" nozzles. As soon as dry, the coating appears white and if portions of the trees have escaped application these are readily noticed. The trees should be carefully examined and if it is found that any part, no matter how small, has escaped, it should be sprayed, even if necessary to drive through with the pumps a second time.

In large orchards the lime-sulphur-salt mixture can be made most economically and rapidly by using live steam and boiling the materials in tanks or barrels. Such an outfit is shown on following page (Fig. 2).

SUMMER TREATMENT.

For several years past the use of a ten per cent. oil emulsion or a dilute whale-oil soap solution has been considered about the only available summer treatment for San Jose Scale. During the past year, however, Prof. W. M. Scott conceived the idea of using the lime-sulphur-salt as a summer wash on the trunks and limbs of scale-infested trees. It has been tested at several points in the State and has proven highly satisfactory as a means of checking the scale. The regular strength, as given in the formula above, is used, the wash being applied to the trunks and larger limbs with a mop or paint brush. None of the mixture is placed upon the foliage or young growth and of course does not affect

(From original photo by W. M. Scott.)

Fig. 2. PREPARING LIME-SULPHUR-SALT WITH THE AID OF STEAM. Orchard of Ohio Fruit Land Co., Myrtle, Ga.

the scale upon these parts. The killing of practically all scale upon the trunk and large limbs not only materially reduces the scale already upon the tree, but checks the rapid rate of increase. Infested trees thus treated during the summer months have a much better chance of withstanding the attacks of the scale until thorough winter treatment can be undertaken.

CONCLUSIONS.

(1) That for successful control of the San Jose Scale, thorough winter treatment must be adopted. Summer treatment, while extremely valuable for checking scale in recently discovered cases, can not alone prevent serious damage to the trees.

(2) That a thorough spraying with the lime-sulphur-salt wash in December and again in late February or early March, is the most effective treatment for San Jose scale that has yet been devised.

(3) That a single spraying with lime-sulphur-salt in February or early March is more effective than the same application made in December or January, and is slightly more effective than winter treatment with 20 per cent. crude oil or kerosene.

(4) That the lime-sulphur-salt mixture is entirely harmless to deciduous fruit trees if applied when these are in a dormant condition, *but that its application after the buds begin to open will result in injury to the latter and to the twigs.*

SPRAY PUMPS.

For general orchard work in the application of such mixtures as oil emulsion, the lime-sulphur-salt wash and Bordeaux mixture, a strong, well-made barrel sprayer is usually the most useful. Among those that deserve mention here are the "Pomona," manufactured by the Goulds Manufacturing Co., Seneca Falls, N. Y.; the "Advance," manufactured by the Deming Co., Salem, Ohio, and the "Eclipse," manufactured by Morrill & Morley, Benton Harbor, Mich. The Field Force Pump Co., Elmira, N. Y., the Bean Pump Co., Hudson, Mich., the Myers Pump Co., Ashland, Ohio, Geo. H. Stahl, Quincy, Ill., and the Spray-Motor Co., Buffalo, N. Y., are also manufacturers of good spray pumps.

The Beck & Gregg Hardware Co., and the Cotton States

Belting and Supply Co., both of Atlanta, Ga., also handle spraying machinery.

Each pump should be fitted with two leads of twenty or twenty-five foot discharge hose, Vermorel nozzles and cut-off cocks. An order for a pump should specify that these attachments are wanted.

For use in yards, gardens and family orchards a knapsack pump will usually be sufficient. Even a small bucket pump may be found useful for light work. These may be obtained from almost any manufacturer of spray pumps.

GEORGIA

State Board of Entomology

BULLETIN No 9 January, 1904

The Cotton Caterpillar

BY
WILMON NEWELL

Capitol Building : Atlanta, Ga.

Georgia State Board of Entomology.

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P. J. BERCKMANS, Pres. of State Horticultural Society, Augusta.

DUDLEY M. HUGHES, Pres. of State Agricultural Society, Danville.

WILMON NEWELL, State Entomologist and Secretary of the Board, Atlanta.

R. I. SMITH, ... Assistant State Entomologist, Atlanta.

GEORGIA

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Capitol Building : Atlanta, Ga.

Fig. 1. Dusting cotton with Paris green and lime for cotton caterpillar. (See p. 7)

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THE COTTON CATERPILLAR.

(*Aletia argillacea* Hübn.)

During the summer of 1903 the cotton caterpillar was the cause of considerable damage in several counties of southern Georgia, notably in Baker, Crawford, Chatham, Dooly, Houston, Laurens, Lowndes, Macon, Mitchell, Pulaski, Randolph, Stewart, Sumter and Taylor counties. While the damage in any one locality was not excessive, yet the loss in the aggregate amounted to considerable and in many of the infested fields the "top crop" was entirely destroyed. The experience of previous years has shown that the caterpillars appear in destructive numbers at irregular intervals. The seasons of greatest destruction are usually separated by intervals of several years immunity from the pest. It has also been noted that the most destructive seasons of caterpillar injury have been preceded by one or two years in which the worms were present in greater or less numbers. This was the case in 1866,* when damage was widespread throughout the South and in some localities reached as high as 40 per cent. of the crop. 1867 brought considerable damage, about equal to that of 1866. 1868, however, was perhaps the most serious "caterpillar year" ever experienced. Weather conditions had evidently been such as to favor the constant increase of the insects through '66 and '67, resulting in vast armies of caterpillars in 1868. Damage by the caterpillars again commenced in 1871, increased in 1872, and 1873 wit-

*Fourth Rept. U. S. Ent. Comm. p. 26.

nessed one of the most destructive seasons on record.

Conditions at the present time seem favorable for the recurrance of the caterpillars in 1904, and while their appearance cannot even be predicted with any degree of certainty, the comparative freedom from parasites in 1903* make it advisable for the planter to be properly prepared for combating the pest should it appear. It has therefore been deemed expedient to place in the hands of the Georgia planters a brief description of the pest and the most successful measures which have been used against it.

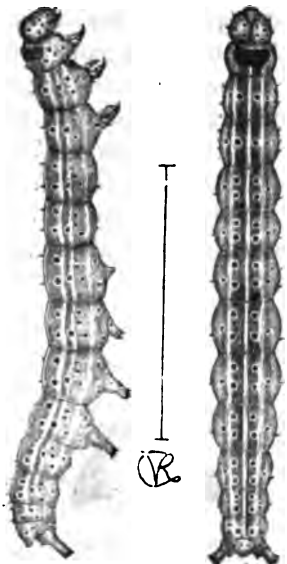
Life History.

The egg is of a greenish blue color and is about one-thirtieth of an inch in diameter. It is deposited usually upon the under side of the lower leaves of the cotton plant but during the later part of the summer is also frequently found upon the leaves near the top of the plant and occasionally upon their upper surfaces. The eggs are deposited singly and several sometimes appear upon a single leaf, but they are never found in clusters. The eggs of lace-wing flies (*Chrysopa*) are often mistaken by the planter for those of the caterpillar moths. The eggs of *Chrysopa* are pure white in color, occur in clusters, and each egg is supported upon a tiny thread or pedestal. As the larvæ of the lace-wing flies feed for the most part upon plant lice and are therefore beneficial, these egg clusters need cause no alarm. In warm humid weather the egg of *Aletia* hatches in from three to four days time into a minute caterpillar or "worm." This larva is of a yellowish color and but little larger than the egg. It at once commences feeding upon the underside of the cotton leaf and as it grows, molts or sheds its skin. In a short time the worm is large enough for its characteristic markings to be plainly seen. The larva has three pairs of well-developed legs at the anterior end of the body, and five pairs of "abdominal" or pro-legs.† The caterpillar moves from point to point by the familiar looping motion of the "measuring-worms."

As the larva grows a plain white line is noticed running down the middle of the back. This is followed on each

*From several hundred larvæ which were reared to maturity in closed cages, only one individual parasite was secured. This specimen has been determined by Mr. D. W. Coquillett of the U. S. Div. of Entomology as *Euphorocera claripennis* Maeg.

†The anterior pair of pro-legs is so reduced in size as to appear on the more mature caterpillars as mere tubercles.



a b

Fig. 2. Cotton Caterpillar; *a*, from side, *b*, from above—twice natural size

(After Riley, Fourth Rept. U.S. Entom. Comm.)

side by a row of fine black spots succeeded by another white line. The under side of the caterpiliar is uniformly light with a yellowish or greenish tinge. The general color of the "worms" varies from a light greenish yellow to very dark or almost black. This variation is so great that one is almost persuaded that two distinct species are present. At certain seasons the lighter worms may predominate and at others the darker ones, but it is not unusual to find caterpillars of both color extremes feeding upon the same plant and occuring in about equal numbers. The caterpillar stage lasts from one to three weeks, being shortest during warm and moist weather during midsummer and longer during the cooler spring and autumn months. After the second molt the caterpillar eats entirely through the leaf and the characteristic "ragged" appearance of the foliage is produced. The greater part of the feeding is done during the night and upon cloudy days, although upon bright days many may be found feeding upon the more shaded parts of the plant. Early in the season, while the worms are not numerous, the feeding is confined almost entirely to the leaves and to the "shuck" or involucre of the boll. Later in the season the larvæ may at times eat even the squares and green bolls.

When the larva reaches maturity it folds over the edge of a cotton leaf—usually on the under side—and in the sack thus formed proceeds to enter the pupal or chrysalis stage. The larva spins a few silken threads, sufficient to hold the edges of the leaf together, and after becoming somewhat shorter and thicker, changes to a dark brown chrysalis. At times these pupae will be found suspended from the under sides of the leaves without any protec-

tion in the way of cocoons or folded leaves. This is especially true when the worms have become abundant and the cotton plant severely defoliated. The chrysalis stage lasts from one to three weeks and during this period the insect takes no food. For this reason, and owing to the fact that it is usually well protected within the folded leaf no successful measures can be taken against it at this time. At the end of the pupal stage the skin of the chrysalis splits open along the back and the adult moth emerges.

Fig. 8. Cotton caterpillar moth: *a*, with wings expanded, *b*, wings closed, at rest—natural size. (After Riley, Fourth Rept. U. S. Entom. Comm.)

The adult is an olive-gray moth, not unlike the so-called "candle-flies" with which all planters are familiar. It measures from one and one fourth to one and one-half inches across the wings when the latter are expanded. When seen in bright light the wings have an irridescent purplish appearance and each fore-wing has near its center a well marked spot of darker color. The moth flies largely at night and at this time deposits its eggs upon the cotton plant. During the day the moths may be found hiding in the dense foliage of the cotton plants or n nearby weeds and grass. When disturbed they dart away in a rapid zig-zag flight and are very difficult to capture. The adult does not injure the cotton, although it feeds upon the nectar secreted by the glands upon the squares and bolls, and also visits the flowers of various other plants. They have been known to puncture ripening fruits, especially pears and thereby do considerable injury. The period of egg deposition extends through several days or weeks and a single female may deposit from three hundred to six hundred eggs.* This, together with the fact that an entire generation, from the time of egg deposition until the adult moth is hatched from the chrysalis, may develop in from three to four weeks, accounts for the extremely rapid increase of the caterpillars in an infested field.

*Farmers Bull. No. 47, U. S. Dept. of Agr., p. 5.

PARASITES AND THE EFFECT OF WEATHER CONDITIONS.

The various severe attacks of the cotton caterpillar during the history of cotton cultivation in the United Sates, have been almost invariably followed by years of practical immunity from the pest. This has in some cases been due to attacks upon the egg and larval stages of the pest by a number of parasitic insects, and in other cases the prevailing weather conditions have so reduced the number of caterpillars as to leave practically no adults to hibernate until the following year. At least twelve parasitic species of insects are known to attack the eggs and caterpillars. Upon the first appearance of the caterpillars after a succession of years in which they have been scarce, the parasites are very few in numbers. As the caterpillars increase, an increase in parasites also occurs, but until several months or seasons have elapsed this increase does not keep pace with that of the caterpillars. Only when the host insects are exceedingly abundant are conditions most favorable for the parasites and then sooner or later their rate of increase may exceed that of the caterpillars and the ravages of the latter be checked or stopped entirely. Moist and cloudy weather is especially favorable to the rapid development of the caterpillars, while hot dry days at the time of hatching from the egg, or shortly afterwards, may destroy large numbers. Many of the larvae fall from the plants to the ground and if there exposed to the direct hot sunshine may be unable to again reach the foliage. It is evident that in fields where the rows are far enough apart to allow plenty of sunshine to reach the ground, this destruction will be much greater than where the rows are close together and the ground thoroughly shaded. This should be borne in mind at the time of planting and the rows placed sufficiently far apart to admit plenty of sunshine. Aside from this method of planting being a not invaluable precaution against the caterpillar, it also decreases materially the damage from boll worm injury. In Texas where extensive experiments have been conducted against the Mexican cotton boll weevil, it has been found

that wide rows are of value in decreasing the damage done by this pest, and it has also been shown that cotton planted reasonably far apart, produces more per acre than that which is planted close, even where insect damage is not taken into account.

REMEDIES.

The first step in devising remedies for any insect pest is a careful consideration of all points in its life history. From what has been said above upon the habits of the caterpillar, it is at once evident that it cannot be successfully fought in the egg or pupal stage. While there is a possibility of capturing the moths by means of trap-lights set in the fields at night, this plan is not particularly effectual. The larva is a voracious feeder and can be killed by poisoning the foliage upon which it feeds. Much has been written in regard to treatment for this insect, but wishing to test some of the more promising methods and test their reliability in actual practice under conditions prevailing in the Georgia cotton fields, this department carried on a number of experiments during the summer of 1903. These are given in detail below.

EXPERIMENTS AGAINST THE COTTON CATERPILLAR IN 1903.

In August word reached us that the caterpillars were severely injuring the cotton near Montezuma, in Macon county. We at once visited that locality and upon the plantation of Mr. Yancey Hill found the worms severely defoliating the cotton in a field of about 8 acres, and spreading rapidly to adjoining fields. At this time the majority of the larvae were nearly full grown, and a considerable percentage had already "webbed up," i. e., had entered the pupal stage. The conditions were therefore unfavorable for spraying tests but these were at once undertaken. On August 22nd, several plats were treated as follows:

Plat. 1. A dusting apparatus was made from a one-inch board, 4 1-2 feet long and 3 inches wide, by boring an inch and a half auger hole five inches from each end and

attaching under each hole a sack five inches wide by about fifteen inches long. These sacks were made from unstarched sheeting running about 4 pounds to the yard. This duster is shown in Fig. 4. A mixture was then made of 1 part Paris green and 4 parts air-slaked lime. The sacks were filled with this mixture and the latter dusted upon the plants by walking rapidly along the rows, and holding the duster in such a manner as to distribute the poison upon both sides of the row at once. (See Fig. 1.) The method, frequently recommended, of distributing Paris green from sacks attached to a pole and carried upon a mule or horse, was also tried, but with very unsatisfactory results. The irregularity of the wind made an equal distribution impossible and the large amount of poison getting upon the operator and the mule made this method disagreeable and even dangerous.

Plat 2 was sprayed, using a knapsack pump, with 1 pound of Paris green and 1 1-2 pounds of lime per 100 gallons of water.

Plat 3 was sprayed with 2 pounds of Paris green and 3 pounds of lime per 100 gallons.

Plat 4 was sprayed with 3 pounds of Paris green and 4 pounds of lime per 100 gallons.

Plat 5 was sprayed with 1 pound of arsenate of lead (Bowker's Disparene) to each 50 gallons of water.

Plat 6 was sprayed with 2 pounds arsenate of lead per 50 gallons.

Plat 7 was sprayed with 3 pounds arsenate of lead per 50 gallons.

Examinations of all plats were made on August 25, three days after the treatment. The average number of pupae and larvae per hill in each plat on August 25th is given in the table below.

Plat No.	Treatment August 22	Number of pupae and larvae per hill August 25		
		Ave. No. of pupae per hill	Ave. No. of larvae per hill	Injury to the foliage by the application
1	Dusted with Paris green 1 part, lime 4 parts.	2.11	0	None
2	Sprayed P. green 1 lbs., lime 1½ lbs., water 100 gal.	1	.3	None
3	Sprayed P. green 2 lbs., lime 3 lbs., water 100 gal.	1.7	0	Slight
4	Sprayed P. green 3 lbs., lime 4 lbs., water 100 gal.	2.7	.1	Slightly more than in No. 3
5	Arsenate of lead 1 lb., water 50 gal.	3	0	None
6	Arsenate of lead 2 lbs., water 50 gal.	3.1	0	None
7	Arsenate of lead 3 lbs., water 50 gal.	3	0	None
8	UNTREATED	7	1	———

From the above it will be noted that in spite of the unfavorable conditions and the fact that the larvae were many of them matured at the time of treatment, an average per hill of only 2.7 pupae were found on all the treated plats, as against an average of 7 pupæ per hill in the plat receiving no treatment. Also at the time of examination there still remained an average of one caterpillar per hill in the unsprayed plat and an average of but one caterpillar per ten hills in the treated areas. The spraying with Paris green appeared somewhat more effective against the caterpillars than did that with the arsenate of lead and slightly more effective than the application of Paris green

and lime in dry form. The latter method, however, presents more advantages in the rapidity with which the material can be prepared and applied. With the duster described above and shown in Figs. 1 and 4, we found that each hand employed could apply the poison at the rate of 10 to 15 acres per day, whereas not more than 3 to 4 acres per day could be covered by using the knapsack sprayer. For general practice the application of Paris green in powder form is preferable to spraying. In rainy weather the rains soon wash the Paris green from the plants and make it almost impossible to keep the plants properly covered with the poison. It is at just such times as this that the caterpillars develop most rapidly and remedies are most needed. The arsenate of lead is very adhesive and is not readily washed off the plants by rains and dews. In rainy weather therefore, when it is impracticable to apply the dust, spraying with arsenate of lead should be resorted to. For this purpose a knapsack or similar pump must be used as larger pumps cannot during midsummer be driven through the fields without breaking down and destroying considerable cotton. The arsenate of lead may be safely applied at the rate of 3 pounds to each 50 gallons of water. Where spraying is necessary we advise the use of arsenate rather than Paris green, not only on account of its adhering to the foliage better, but because it is not nearly so likely to burn the leaves. In the experiments mentioned above it was found that the Paris green mixture of 2 pounds per 100 gallons burned the foliage slightly and the mixture of 3 pounds per 100 gallons burned the foliage rather severely. No injury was manifest where arsenate of lead was used. The burning effect of the Paris green was most pronounced upon those plants which had been severely "ragged" by the caterpillars.

In all cases the younger larvae succumb most readily to the poison, and the great advantage of applying poison as soon as the first caterpillars appear is evident. Not only are they more easily killed at this time but every one destroyed early in the season is of as much advantage to the planter as the destruction of several hundred later on.

Fig. 4. Dusting apparatus for applying Paris green and lime for cotton caterpillars.

DANGER OF POISONING LABORERS OR STOCK.

After applying the poison, stock of all kinds should be kept from the plants, or if necessary to drive through the fields, the horses or mules should be muzzled. We would not advise the pasturing of stock in the treated fields at any time during the season, despite the fact that a few good rains will remove practically all Paris green from the plants. When arsenate of lead is used greater precaution should be taken, as on account of its adherent character this poison will remain upon the plants for a considerable time. While both Paris green and arsenate of lead are deadly poisons when taken internally, they can be safely handled. No precautions, aside from reasonable care in handling need be taken, unless it is to prevent the entrance of the poison into open sores or cuts upon the face and hands. There is no danger of cotton pickers being poisoned as a result of spraying or dusting, unless a very large number of bolls are open at the time of treatment. Even in this case no unpleasant results will follow if the pickers use reasonable care in handling the cotton.

CONCLUSIONS.

1. That arsenical poisons should be thoroughly applied to the cotton plants upon the very first appearance of the caterpillars.

2. That in moderately dry weather this application can best be made in the form of dust, a dry mixture of 1 part Paris green to 4 parts fine air-slaked lime as directed above. The distribution of this mixture should be so gauged as to use from 1 to 1 1-2 pounds of Paris green per acre. If the laborers exceed this amount the proportion of lime should be increased or sacks of finer texture used upon the duster.

3. That in wet weather a mixture of arsenate of lead at the rate of 3 pounds to each 50 gallons of water applied with a knapsack spray pump, will adhere better and be more effectual against the caterpillars than the applications of Paris green.

GEORGIA

State Board of Entomology

BULLETIN No. 10. April, 1904.

THE CROP PEST LAW OF GEORGIA.

Regulations of the Georgia State Board of Entomology

CAPITOL BUILDING : : Atlanta, Ga.

ATLANTA, GA.
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1904

Georgia State Board of Entomology

ORGANIZATION.

O. B. STEVENS, Chairman, Commissioner of Agriculture, Atlanta.

P. J. BERCKMANS, Pres. of State Horticultural Society, Augusta.

DUDLEY M. HUGHES, Pres. of State Agricultural Society, Danville.

WILMON NEWELL, State Entomologist and Secretary of the Board, Atlanta.

R. I. SMITH, ... Assistant State Entomologist, Atlanta.

The Crop Pest Law of Georgia*

Be it enacted, by the General Assembly of Georgia:

Organization of State Board of Entomology

Section 1. That from and after the passage of this Act, the Commissioner of Agriculture of the State of Georgia, the President of the Georgia State Horticultural Society and the President of the Georgia State Agricultural Society shall, ex-officio, constitute a Board to be known as the State Board of Entomology, of which the Commissioner of Agriculture shall be chairman, which Board shall have full power to enact such rules and regulations governing the inspection, certification, sale, transportation and introduction of trees, shrubs, cuttings, buds, vines, bulbs and roots, that they may deem necessary to prevent the further introduction, increase and dissemination of insect pests and plant diseases.

Offices of the Board

Sec. 2. That the State Entomologist appointed by the Commissioner of Agriculture, under the provisons of the Act cited above, approved December 21, 1897, shall act as an inspector under the provisions of this Act; and it shall be the duty of the said Board to promulgate rules and regulations in accordance with this Act for the government of the said Entomologist in the duties devolving upon him in the execution of the provisions of this Act.

Appropriation

Sec. 3. That the salary of the said Entomologist shall not exceed one thousand and five hundred dollars per annum, and that said salary shall be paid out of the funds in the Agricultural Department arising from the inspection of oils. In addition to the above appropriation the sum of three thousand and five hundred dollars per annum is hereby appropriated out of the funds in the Agricultural Department arising from the inspection of oils, for the purpose of defraying the expenses of the execution of this Act, the equipment of a laboratory, the traveling and other incidental expenses of the Entomologist, and the issuing of reports and other publications. The Board may also employ such assistants to the Entomologist as may be deemed necessary.

Appeal from decision of Entomologist—stay of proceedings

Sec. 4. The Entomologist shall have power under the regulations of the Board of Control, to visit any section of the State where such pests are supposed to exist, and shall determine whether any infested trees or plants are worthy of remedial treatment or shall be destroyed. And he shall immediately report his findings in writing, giving reasons therefor, to the owner of the infested plantation, his agents or tenants, and a copy of each report shall also be submitted to the said Board. In case of objection to the findings of the Inspector, an appeal shall be made to the said Board, who shall have the power to summon witnesses and hear testimony on oath, and whose decision shall be final. An appeal must be taken within three days and shall act as a stay of proceedings until it is heard and decided.

*Acts of the General Assembly of Georgia, approved Dec. 21, 1897, Dec. 20, 1898 and Dec. 21, 1900.

Section 5. Upon the findings of the Inspector in any case of infested trees or plants, the treatment prescribed by him shall be executed at once (unless an appeal is taken), under his supervision; cost of material and labor shall be borne by the owner; *Provided, however,* that in case the trees or plants shall be condemned, they shall be destroyed by the Inspector, and the expense of such action shall be borne by the owner. No compensation shall be allowed for any plants that shall be destroyed.

Treatment and destruction of infested trees or plants

Sec. 6. In case any person or persons refuse to execute the directions of the Inspector or of the said Board after an appeal, the County Judge, or Ordinary shall, upon complaint filed by the Inspector or any freeholder, cite the person or persons to appear before him within three days notice after being served, and that the said Judge or Ordinary may hear and determine all these cases in vacation; and, upon satisfactory evidence, shall cause the prescribed treatment to be executed, and the expense thereof and costs of court shall be collected from the owner or owners of infested plants.

Hearing before Judge or Ordinary

Sec. 7. It shall be unlawful to offer for sale, sell, give away or transport plants, scions, buds, trees, shrubs, vines or other plants, tubers, roots, cuttings, bulbs, known to be infested with dangerously injurious insects or plant diseases. Any person or persons violating this section shall upon conviction thereto be guilty of a misdemeanor.

Unlawful to sell, give away or transport infested stock

Sec. 8. The said Board of Control, its agents or employees, are hereby empowered with authority to enter upon any premise in discharge of the duties herein prescribed. Any person or persons who shall obstruct or hinder them or their agents in the discharge of these duties shall be deemed guilty of a misdemeanor, and, upon conviction thereof, shall be guilty of a misdemeanor.

Authority of Entomologist to enter upon premises

Sec. 9. The Board shall have the power to also adopt rules and regulations, not inconsistent with the laws and Constitution of this State and the United States, for preventing the introduction of dangerously injurious crop pests from without the State, and for the governing of common carriers in transporting plants liable to harbor such pests to and from the State, and such regulations shall have the force of laws.

Power of Board to adopt Rules and Regulations

Sec. 10. It shall be unlawful for any grower, nurseryman or corporation to ship within the State of Georgia any trees, shrubs, cuttings, vines, bulbs, roots without having been previously inspected by either a State or Experimental Station Entomologist or government officer, within twelve months of the date of said shipment, and certificate of inspection to accompany each box or package. Violation of this clause will be considered as a misdemeanor and punishable as such.

Unlawful to ship trees without certificate—punishment

Sec. 11. Be it further enacted, that the members of the said Board, any two of whom shall constitute a quorum in the absence of the third, shall, within 30 days from the passage of this act, draw up and promulgate through the press of the State the rules and regulations necessary to carry into full and complete effect the provisions of this Act, carefully defining what diseases or maladies, both insect and fungus, shall constitute infes-

Board to designate insects and diseases that constitute infestation

tation in trees or plants within the meaning and purview hereof.

Nurseries to be inspected prior to Nov. 1st. of each year.

Sec. 12. Be it further enacted, that any person or persons residing in the State of Georgia, dealing in or handling trees, etc., shall be compelled to have his or their stock inspected annually on or before the 1st of November of each year. If, upon such inspection, such stock is found to conform to the requirements of the Board of Control, the Inspector shall furnish a certificate to that effect. And any such person or persons making a shipment before the filing of such certificate with the chairman of the Board of Control, shall be guilty of a misdemeanor.

Shipment of nursery stock from without the State.

Sec. 13. Each and every person residing in States or Countries outside of the State of Georgia dealing in or handling trees, plants, cuttings, vines, shrubs, bulbs and roots in this State, shall register his name or firm and file a copy of his or its certificate of inspection furnished by the Entomologist, Fruit Inspector or duly authorized government official of his State or Country, with the Chairman of the Board of Control. Upon failure so to do, said stock shall be liable to confiscation under order of the Inspector.

Services of Inspector—how secured

Sec. 14. When two reputable citizens of any county in Georgia shall notify the Board, from belief, that noxious insects or plant diseases exist in their county, the said Inspector shall be directed to ascertain as speedily as possible by personal investigation, and in such other manner as he may deem expedient, the extent of the infection, and shall act with all due diligence to suppress and eradicate the said pests and give notice to the owner, tenant or agent of such premises to treat such infested plants acording to the methods he may prescribe, or destroy them within ten days from date of such notice, and if after the expiration of such period of ten days the infested plants have not been treated or the treatment has not been properly applied or is not effectual in ridding plants of the pests, the Inspector shall cause such plants to be properly treated or destroyed as his judgment warrants. The cost of the work shall be covered by execution from the owner of the premises.

Cost of treatment—how collected.

Monthly and Annual Reports.

Sec. 15. It shall be the duty of the Inspector to make a monthly report of his work, both as Entomologist and Inspector, to the Board of Control, as well as the expenditure under this Act, and said Board shall report annually to the Governor of the State.

This act shall take effect from and after its passage, and all laws and parts of laws in conflict with this Act are hereby repealed.

RULES AND REGULATIONS
OF THE
Georgia State Board of Entomology.

At the annual Meeting of the Board held at Macon, Ga., Jan. 6th, 1904, the Rules and Regulations of the Board were amended to read as follows:

Rules and Regulations for the Government of the State Entomologist in the Enforcement of the Act of the General Assembly of the State of Georgia, Providing for the Control and Eradication of the Insect Pests and Fungous Diseases which Threaten the Fruit and other Agricultural Industries of the State, and for the Prevention of the Further Introduction of Dangerously Injurious Crop Pests from Without the State.

In pursuance of an Act of the General Assembly of the State of Georgia, approved December 21, 1897, and amended December 20, 1898 and December 21, 1900, creating a Board of Entomology and authorizing and directing the same to take action for the suppression of certain hereinafter defined injurious insects and fungous diseases, and for the prevention of the further introduction, increase and dissemination of the same, the following rules and regulations are hereby enacted and promulgated:

Pests and diseases constituting infestation

1. In accordance with section 11 of said Act, the following insects and fungous diseases are hereby declared, individually and severally, to constitute infestation in trees and plants; this list to be revised at the will of the Board of Entomology:

The San Jose Scale (*Aspidiotus perniciosus.*)
The New Peach Scale (*Diaspis pentagona.*)
The Woolly Aphis of Apple (*Schizoneura lanigera.*)
Black Knot of Plum and Cherry (*Plowrightia morbosa.*)
The Crown Gall (*Dendrophagus globosus.*)
The Mexican Cotton Boll Weevil (*Anthonomus grandis.*)
Rosette of Peach and Plum.
Yellows of Peach.

Location of pests—directions for treating same

2. The State Entomologist is hereby charged with the enforcement of said Act, and as inspector is directed to locate by personal investigation, correspondence and in such other manner as he may deem best, the above-named pests so far as they may exist in this State, and give proper directions and take such steps in accordance with the above-cited Act as he may deem necessary to control or eradicate the same.

Power of Entomologist to destroy infested plants, etc.

3. In accordance with Section 5 of the above-cited Act, the State Entomologist is hereby endued with power to condemn and destroy any infested trees, shrubs or other plants that in his judgment are not worthy of remedial treatment, when such infestation is, or is likely to become, a menace to the agricultural interests of any section of the State, or when the owner or owners of infested premises shall refuse or neglect to properly execute the treatment prescribed for him or them.

Trees, plants, etc., shipped without certificate attached—liable to confiscation.

4. Any trees, shrubs or other plants commonly known as nursery stock, shipped within the State of Georgia, without each box, bundle or package (in each car-load, or less than car-load lot) being plainly labeled with the official Entomologist's certificate to the effect that the contents of same have been inspected and found to meet with the requirements of the Board of Entomology in accordance with Section 10 of the Act cited above, shall be liable to confiscation upon the order of the inspector.

No trees, plants etc., to be sold or delivered without certificate attached

5. No trees, shrubs or other plants commonly known as nursery stock shall be sold, delivered or given away within the State of Georgia without being plainly labeled with the certificate of the State Entomologist.

Nurserymen to apply for inspection before July 1st

6. Persons or firms within the State of Georgia growing for sale trees, cuttings, shrubs, vines or other plants commonly known as nursery stock shall make application to the State Entomologist (Atlanta, Ga.) for inspection and certificate on or before July 1st of each year. Any person, corporation or firm failing to make application to have his or their stock inspected as aforesaid, after receipt of notice of this rule, shall not be permitted to offer for sale in this State any of said stock not inspected; provided that such person, corporation or firm may make written application to the State Board of Entomology to be relieved of his or their default and consequences, and offering to pay any additional expense incurred by the State and its officers by reason of such failure. The Board may upon a proper showing order an inspection of said nursery.

Failure to make application—stock can not be sold

Inspection—how secured in case of default

Nurseries partially infested—procedure

7. In case some part of a nursery shall be found infested with San Jose scale no certificate shall then be granted; provided, however, that isolated blocks of nursery stock not infested, may be considered as separate nurseries and a certificate may be granted covering such stock after all stock in the infested blocks has been destroyed.

Official tag of Board and certificate must be attached to all shipments from without the State

8. Each and every box, bundle or package of trees, shrubs and other plants commonly known as nursery stock, shipped in car-load lots or less than car-load lots into the State of Georgia from any other state or country, shall be plainly labeled with a certificate of inspection furnished by the entomologist, fruit inspector or other duly authorized official in the state or country in which said stock was grown, and also with the official tag of the Georgia State Board of Entomology hereinafter provided for; said tag to be valid only until July 1st following the date of certificate upon which it is based (See Sections 9 and 13 of the Act cited above.) Such

Untagged shipments—liable to confiscation

shipments not so labeled shall be liable to confiscation upon the order of the inspector.

Official tags—how secured

9. Any person or persons residing in states or countries outside of the State of Georgia, dealing in or handling trees, shrubs or other plants in this State, or shipping trees shrubs or other plants therein, shall file with the State Entomologist (Atlanta, Ga.) a certified copy (or signed duplicate of original) of the certificate issued by the entomologist, fruit inspector, or other duly authorized official of the State or Country in which said stock was grown. Such certificate for nurseries south of the northern boundary line of North Carolina, Tennessee, and Arkansas must be based upon an inspection made not earlier than July 1st, and for nurseries north of said line, upon an inspection made not earlier than June 1st. Said person or persons shall also file with the State Entomologist a signed statement in which said person or persons agree to fumigate with hydrocyanic acid gas all stock shipped into the State of Georgia. Such fumigation shall be in a manner approved by the State Entomologist. Upon receipt and approval of the certificate and statement above-mentioned, the certificate of the Georgia State Board of Entomology will be issued to the applicant without charge, and official tags bearing a *fac simile* copy of such certificate and the seal of the State Board, will be furnished the applicant at cost of printing, viz., Sixty cents for the first one hundred or part thereof and twenty-five cents for each additional hundred.

Common carriers forbidden to deliver uncertified stock

10. No transportation company or common carrier shall deliver any box, bundle or package of trees, shrubs or other plants commonly known as nursery stock, shipped from any other State or country to any consignee at any station in the State of Georgia, unless each box, bundle or package is plainly labeled with a certificate of inspection furnished by the official Entomologist of the State or country in which said stock was grown, and also with the official tag of the Georgia State Board of Entomology hereinabove provided for. Such shipments of the nature designated above originating in the State of Georgia, need only have the certificate of the State Entomologist; and unless his certificate is attached to each and every box, bundle or package of trees, etc., they shall not be accepted for transportation.

Transportation Cos. shall notify Entomologist upon receipt of uncertified stock

11. Transportation companies shall immediately notify the State Entomologist (Atlanta, Ga.) when by oversight, negligence or otherwise, any shipment of uncertified stock is received at any station or wharf in the State, and it shall be his duty to proceed as speedily as possible to investigate and dispose of such stock, as provided for in the Act cited above.

All nursery stock must be fumigated

12. All trees, shrubs or other plants commonly known as nursery stock (with the exception of conifers and strawberry plants) offered for sale, sold, or given away in this State shall be fumigated with hydrocyanic acid gas by the grower, under the direction of the State Entomologist.

Failure to fumigate—penalty

Upon failure of any grower or growers to comply with this requirement, certificate shall be withheld or cancelled.

Unlawful to have in possession Mexican Boll Weevil

13. It shall be unlawful for any firm, person or corporation to bring into the State of Georgia, or to have in possession for any purpose, any living Mexican Boll Weevil, or any cotton bolls, squares, plants or seed containing the adult, pupal, larval or egg stage of the Mexican Boll Weevil.

Cotton seed from Texas and La.—must bear certificate of fumigation

14. No cotton seed grown in the states of Texas or Louisiana, or consigned from points in those states, shall be shipped into the state of Georgia without being accompanied by a certificate signed by a duly authorized State or Government Entomologist, stating that said cotton seed has been fumigated in such manner as to kill any boll weevils, larvæ or pupæ which may be contained therein.

Authority of Entomologist to publish bulletins, etc.

15. The State Entomologist is hereby authorized to publish in the form of bulletins, reports, or through the press of the State any matter pertaining to the distribution, life history, habits and treatment of insects pests and fungous diseases, or other matter that may be instructive or aid in the suppression of such pests.

Deputy inspectors—appointment—power of deputy

16. The Board of Entomology may appoint temporary deputy inspectors when it appears to be necessary, to assist the Entomologist in the enforcement of the act cited above, and such deputy inspectors shall have full power to enter on premises and inspect and report to the State Entomologist.

Appeals—how addressed—hearing of

17. Appeals from the decision of the Entomologist should be addressed to the Commissioner of Agriculture, (Atlanta, Georgia), who will notify the appellant of the time and place of hearing such appeal.

Secretary of the Board

18. The State Entomologist shall be Secretary of the Board, and all inquiries relative to the provisions of the above-cited Act and the subject matter of the same should be addressed to him at Capitol Building (Atlanta, Ga.)

* * *

In addition to the above rules, and as further defining the duties of the Entomologist, the State Board of Entomology prescribes the following:

All certificate tags must be secured from Entomologist

All duplicate copies of inspection certificates and shipping tags bearing same, shall be secured from the State Entomologist.

San Jose Scale—paramount pest

The San Jose Scale shall be considered the paramount pest and inspections shall be made with special reference to this insect.

New Peach Scale

Nursery stock infested with the New Peach Scale shall be treated in all respects as is stock infested with San Jose scale.

Crown Gall

Woolly Aphis

Nursery plants found bearing Crown Gall shall be destroyed under the directions of the State Entomologist and a certificate issued to the owner only after he has given reasonable assurance that such infected plants have been or will be destroyed. The same requirement shall apply to nursery trees so badly infested with Woolly Aphis as to have gall formations upon the roots. Plants or trees infested to a lesser degree with this pest shall be treated and allowed to pass inspection.

Rosette and Yellows

Should cases of Rosette or Yellows be found in the

vicinity of a nursery all diseased trees must be destroyed before a certificate is given the owner of the nursery.

Black Knot

In cases of Black Knot occurring in or adjacent to a nursery, certificate will be withheld until all visibly diseased wood shall have been destroyed.

GEORGIA
State Board of Entomology

BULLETIN No. 11—JULY, 1904

I. Fumigation of Nursery Stock
II. Inspection Laws of Other States

BY

WILMON NEWELL.

CAPITOL BUILDING. Atlanta, Ga.

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1904.

Georgia State Board of Entomology

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BULLETIN

OF THE

GEORGIA STATE BOARD OF ENTOMOLOGY.

JULY, 1904. *No. 11.*

Fumigation of Nursery Stock.

The Regulations of the Georgia State Board of Entomology* require that all nursery stock placed upon the market in Georgia shall be fumigated with hydrocyanic acid gas as a precautionary measure against San Jose scale, as well as for the destruction of the woolly aphis and other insects likely to be transmitted from the nursery to the orchard. It should not be understood, however, that fumigation will in all cases eradicate San Jose scale, but when the work is properly done it appears to afford the best protection against this pest that has yet been devised. Impure chemicals, inaccurate scales, undetected leaks in the fumigating house or too close packing of the stock may defeat the object of fumigation and since one can rarely be sure that his fumigating arrangements are working perfectly, it cannot be said that fumigation, affords absolute protection. However results of experiments conducted by this office show that infested trees, can in many cases, be entirely freed from scale by this process. The object of fumigating all nursery stock, after it has passed inspection, is to eradicate (if possible) any slight case of infestation which might be overlooked by an inspector. In this way two safe-guards are provided the orchardist who buys the stock, against the introduction of scale into his orchard, whereas in the case of inspection alone, or of fumigation alone, but one safe-guard is provided him.

The necessary equipment for fumigating nursery stock consists of an air-tight chamber (house or box), a glazed earthenware vessel, a glass measure graduated to ounces,

* Printed in Bulletin No. 10, which will be sent upon request.

and a set of accurate scales. The necessary chemicals are, cyanide of potash (98 per cent.) and sulphuric acid (specific gravity 1.83). Care should be taken to secure the 98 per cent. or 99 per cent. "U. S. P." cyanide,* otherwise an insufficient amount of the gas will be generated and the fumigation prove ineffective. As this substance deteriorates rapidly when exposed to the air, it should be kept in a tightly closed vessel. Its extremely poisonous properties should also be kept in mind and the material not left where it will fall into the hands of children or careless persons. The best commercial grade of sulphuric acid should be procured; it will not do to employ the low grade chamber acid used in the manufacture of fertilizer. The acid should be kept in glass or earthenware vessels, tightly stoppered.

FUMIGATING HOUSES.

The chief requisite for a fumigating house is that it should be air-tight or gas-proof. It should also be of such shape that its cubic contents can be easily determined. The size of the house and the number of rooms contained must of course depend upon the amount of stock to be fumigated. In the case of small nurseries, either of the fumigating boxes described below will be found sufficient. In the case of very large nurseries a house with three, or even four compartments—separated from each other by air-tight partitions—will be found economical, as the work of filling and emptying the rooms can be carried on simultaneously with the fumigation. The house should be on the packing grounds and the stock fumigated as it is dug and brought from the field. A house well adapted to the needs of the average nursery may be built as follows:

Construct two rooms, each 10x10 feet (inside measurement), 10½ feet high in front, and 7½ feet under the eaves, the roof sloping one way only. It is built directly upon the ground, with the sills sunk a few inches in the earth, and either with or without a floor. If on stiff clay, this when well packed, both inside and outside the sills, will answer for a floor. The walls, as well as the partition and roof (and

* Chemical analyses show that the "comercial" cyanide contains an average of 26.45 per cent. of cyanide of potash, while the "U. S. P." article contains an average of 97.22 per cent.

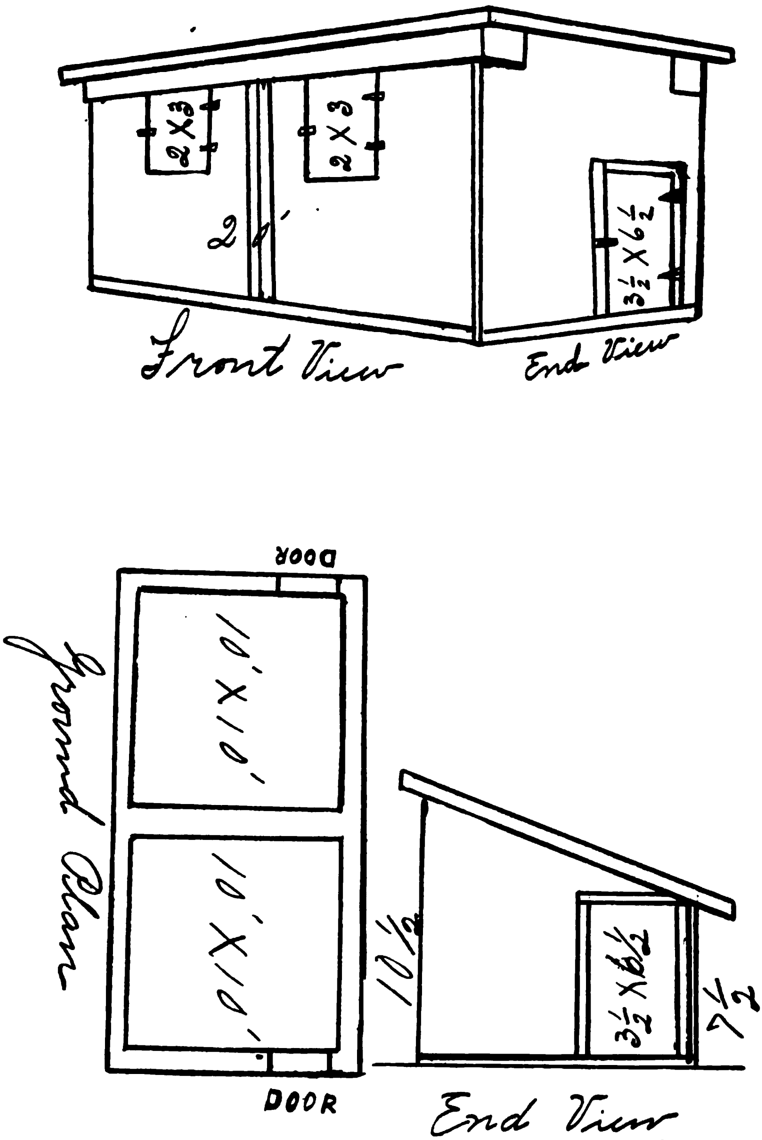

FIG. I. Plan of fumigating house.

floor if clay is not used), should consist of a double course of sheathing or matched lumber with heavy building paper between. Care should be taken to have a smooth surface against which the paper is to fit, and the latter should be lapped three or four inches at all edges and at the corners.

Ordinary unmatched lumber may be used for the outside walls, the boards being fitted snugly together and three-inch strips nailed tightly over all cracks. The inner walls must be in all cases of "tongued and grooved" lumber. After finishing, the interior should be given one or two heavy coatings of paint or white lead to fill all remaining small crevices. The outside of the house should also be painted if it is expected to be safe and serviceable for more than one season.

The roof in addition to being made double, should be covered with tarred roofing paper. A door 3½x6½ feet, made double, refrigerator fashion, should be placed in the end or side of each room. The door should fit accurately, should be swung with three heavy hinges and when closed the edges should come snugly against a felt or rubber seat, thus making it air-tight. In order that the room may be quickly ventilated after fumigation, a window 2½x2½ or 3 feet should be placed at the top opposite the door. Like the latter, this should be made double and should close from the outside upon felt or rubber margins. The entire room, when the door is closed, should show no admission of light.

To permit of a more rapid and general diffusion of the gas a secondary floor should be constructed eight or ten inches above the ground or floor. This is merely a cheap frame-work of slats for supporting the stock, permitting the gas to circulate beneath it. The construction and plan of the house will be made clear by consulting Fig. 1.

Many Georgia nurserymen have constructed fumigating houses in accordance with the above plans, which were published in Bulletin No. 7 about a year ago. Where the amount of stock to be fumigated does not warrant the construction of a two-roomed house, a single roomed house can be built upon the same plan. Such a house is shown in Fig.

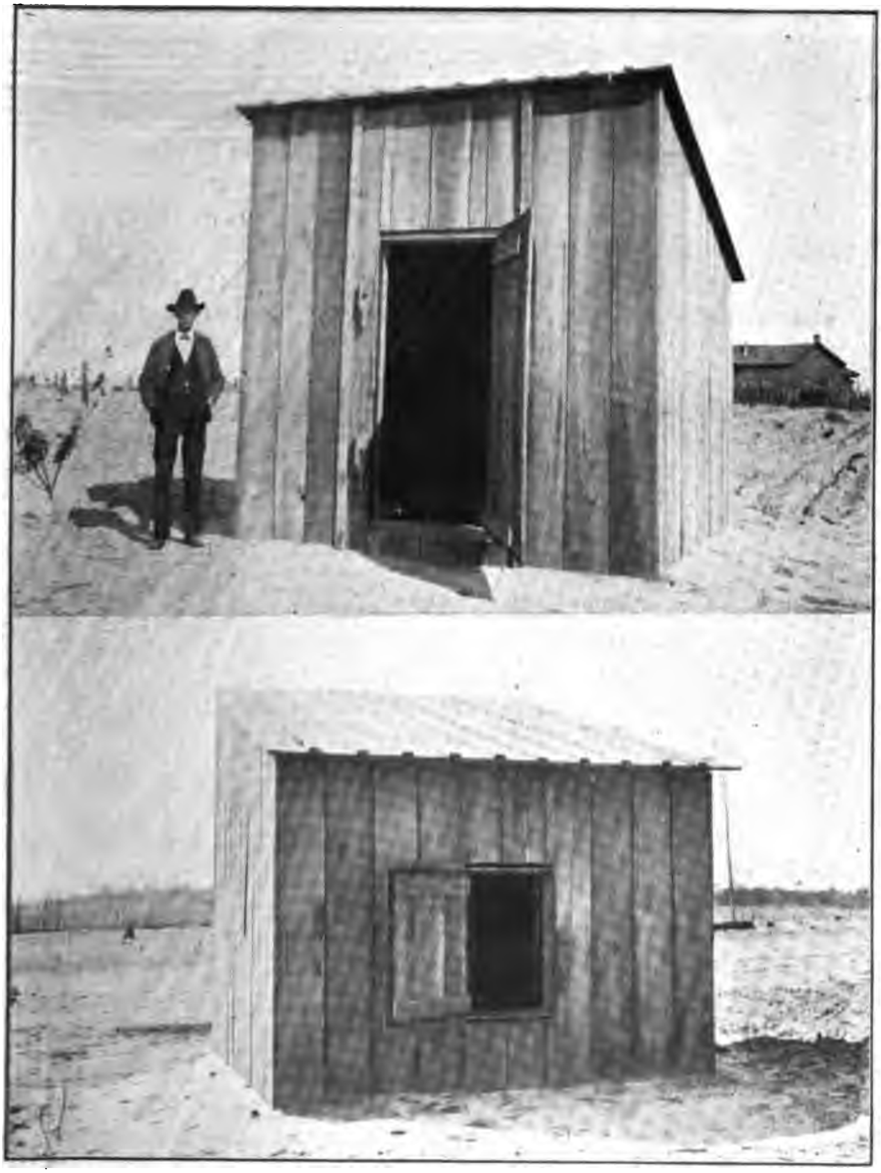

Fig. 2. Front and rear views of fumigating house built by Bond Bros., Roberta, Ga. (Photo by R. I. Smith).

2, and was built by Bond Bros., of Roberta, Ga., at a cost for materials and labor of about $60.00.

The larger nurseries of the State have all constructed houses of considerable capacity. One of the most ingenious and at the same time, durable of these is that built and operated by Smith Bros., of Concord, Ga., and which is shown in Fig. 3. This house is built of concrete and Smith Bros., write as follows regarding it:

"The house is 34 feet long and 14 feet wide. Height to plates, 8 feet 8 inches. It is divided into four rooms, two of them being 12 feet by 13 feet 6 inches, and the other two being 3 feet by 5 feet 6 inches. The two large rooms are used for fumigating heavy nursery stock while one of the smaller rooms is used for fumigating small lots of trees or for cions, cuttings, etc., that require small space The other small room is used for storing chemicals.

The walls are constructed of concrete and are 12 inches thick, plastered over smoothly inside and out and the rooms are also finished overhead by plastering in the usual manner on laths. The plastering on the side and partition walls is applied to the bare concrete and stands alright. The door frames are made of 2 12 inch pine lumber. The doors are ordinary panel doors 3 and 3½ feet wide and 6½ feet high. They are well painted and hence do not shrink or swell in dry or wet weather. The roof is an ordinary frame and shingle roof. The concrete of which the building is constructed is made of broken rock and sand, with enough lime to make a good mortar.

It makes a very durable wall and can be cheaply put up, as little skilled labor is required, and the materials are usually close at hand over the greater part of the country. We used it in our packing house walls, while several stores, a ware house, and recently a bank building here in Concord have been constructed of it.

When regularly running our fumigatorium, the trees come in on the wagons and are unloaded in front of the building where the fumigating gang takes charge of them and fills

FIG. 3. Concrete fumigating house used bv Smith Bros., Concord, Ga. (Photo by R. I. Smith)

up the rooms. When one room is full it is charged and closed up, and then while it is given the usual time, the other room is filled. The rooms are always filled from the front side and emptied from the rear which opens right into the heeling yards. It is a great convenience to have doors opening from both sides.

We are unable to give the exact cost of this building, as we were doing some other similar building at the same time and did not keep the accounts separate. We estimate that one like it could be put up now for about $150.00 wherever sand and stone are within easy reach. We built this one in 1902 and it has given perfect satisfaction in every respect and were we to build a new one now, we do not know that we would vary from this plan in any particular."

COMPUTATION.

The standard formula for fumigating each 100 cubic feet of space contained in the fumigating house is as follows:

1 ounce potassium cyanide (98 or 99 per cent.)

2 fluid ounces sulphuric acid (sp.g. 1.83).

4 fluid ounces water.

The cubic contents of the house should be accurately determined and the amounts of cyanide, acid and water computed from the above formula. For example, the house described on page 4, containing 900 cubic feet, will require for each charge 9 ounces cyanide, 18 fluid ounces of acid, and 36 fluid ounces of water. The glazed earthenware vessel should be somewhat larger than is necessary to hold the above amounts. A one or two-gallon jar is perhaps the best container.

The above strength is used for one-year-old peach and for plum, apple, pear and hardy forest trees, all of which must be perfectly dormant. For June-budded peach as well as for scions, buds, roses and tender plants, two-thirds of above strength should be used, *i. e.*, ⅔ ounce of cyanide (with proportionate amounts of acid and water) per 100 cubic feet. For example, each room of the house shown

in Fig. 1, when fumigating June-budded peach, roses, etc., will require a charge of 6 ounces of cyanide, 12 ounces sulphuric acid, and 24 ounces of water.

Conifers (evergreens) should in no case be fumigated, as they are not known to be infested with San Jose scale and are perhaps more susceptible to injury than are deciduous trees and plants.

Strawberry plants can be effectually fumigated for killing the root-louse and perhaps certain other insects. However, it is very doubtful if they can be safely fumigated with hydrocyanic acid gas which is strong enough to effectually dispose of San Jose scale. We have never known the latter pest to occur upon strawberry plants, except when the latter were growing in close proximity to infested fruit trees. The strawberry root-louse is not known to occur in this State, and we do not therefore deem it necessary or advisable to fumigate strawberry plants. However, shipments of strawberry plants infested with the root-louse will be absolutely prohibited and nurserymen of other states who intend to ship strawberry plants into Georgia should see that their inspection certificates certify to apparent freedom from this pest.

FUMIGATING THE STOCK.

Fumigating.—The trees, as dug and brought from the field, should be placed in the fumigating house, care being taken to see that they are free from any considerable quantities of mud or dirt. Trees should not be fumigated when they are wet, as it has been shown that in this condition they are likely to be injured by the gas.* No moss or other packing should be about the trees nor should the bundles be too closely tied or packed. When the compartment is filled with stock, close the window securely and place the generating jar on the floor near the middle of the room. Pour into it the required amount of water and then slowly pour in the acid. The cyanide previously weighed and enclosed in a tight paper bag, is now dropped into the jar and the door quickly and tightly closed. The steps in this operation

* Smith J. B., 23d An. Rep. N. J. Ex. Sta., 1902, p. 494.

should never be varied. If water is poured into the acid a violent action takes place and may be the cause of injury to the operator. Enclosing the cyanide in the paper bag makes it convenient and safe to handle and also retards the generation of the gas for a moment after being dropped, in thus allowing time to leave the room and close the door securely.

The extremely poisonous nature of both the solid cyanide and the gas must always be borne in mind. The solid is best handled with forceps or wooden paddles as much as possible, and should never be handled by a person having open sores, cuts or bruises upon the hands, as the entrance of the poison into such may result seriously. The gas is colorless and if inhaled in quantity is fatal. Smaller amounts induce headache or dizziness.

After the generator has been started the room should be kept closed for forty minutes, at the end of which time the door and window should be thrown open, care being taken to avoid the outward rush of gas. After fifteen minutes of airing, the room may be safely entered and the stock removed, being now ready for packing or heeling in. After fumigation the contents of the jar should be buried.

FUMIGATING BOXES.

For fumigating nursery stock in small lots it is sometimes convenient to use a tight box of known capacity instead of a house. A box ten feet long, three feet four inches deep and three feet wide (inside measurement) is a convenient size for the small nursery. A box similar to the one described in Johnson's "Fumigation Methods" (p. 94) is now in use among the smaller nurserymen of Georgia, and may be made as follows: (See Fig. 4.)

Use plain matched three-quarter inch ceiling, making walls, top and bottom double, with heavy building or tarred paper between. Make the uprights of 2x6-inch stuff and reinforce the corners with $1\frac{1}{4}$x3-inch stuff and 2x3-inch battens. The upper edges of the box should be covered with felt, securely glued on so as to make an air-tight cushion-joint when the top is on. All parts of the box, including the cover, should be given a heavy coat of white lead. On each end of

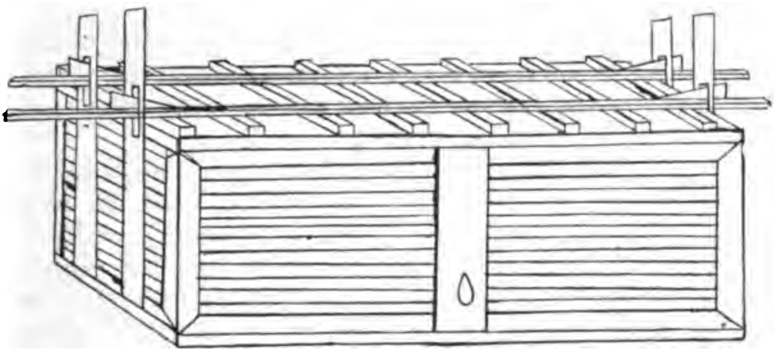

FIG. 4. Fumigating box with cover.

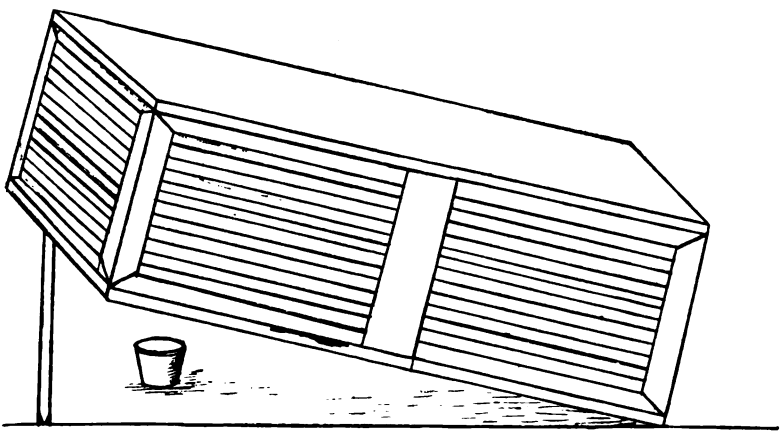

FIG. 5 Fumigating box without cover, showing generating jar ready to receive chemicals.

the box should be nailed two 2x6-inch beams with mortised ends projecting a few inches above the top for keying down the cover. A slat framework (removable) should be placed eight or nine inches above the floor to support the trees and to allow better circulation of the gas.

On one side about seven inches from the bottom and directly over the point where the vessel is to be placed, an inch and a half auger-hole should be bored, slanting downward. Two funnels should be provided, one for the acid and water. and the other for the cyanide; also a tightly fitting plug to close the hole after the chemicals are in. A small door about 8x8 inches, double, swung on hinges and closing upon the felt or rubber margins is even preferable to the hole. With the door the cyanide can be placed in a paper bag and dropped into the acid and water mixture as indicated above for fumigating houses.

In operation the empty vessel is placed on the bottom of the box, just underneath the hole or door, the false bottom inserted and the box filled with nursery stock. The cover is then placed upon the box and two 2x8-inch timbers, eleven feet long, are placed lengthwise the top with the ends inserted in the mortises of the uprights and are keyed down tightly with wooden wedges. The required amounts of water, acid and cyanide are now poured through funnels into the dish in the order named, using one funnel for cyanide only. The hole is then tightly plugged.

If a door is used funnels of course are unnecessary. For fumigating apple and pear stock, plums and peaches one year old, the charge is as follows:

1 ounce cyanide,
2 ounces sulphuric acid.
4 ounces water.

For fumigating June-budded stock and for roses, buds and scions, the following charge should be used:

2/3 ounces of cyanide.
1 1/2 ounce sulphuric acid.
3 ounces water.

In both cases the stock should be exposed to the gas for forty minutes.

A cheaper but less convenient box can be constructed the same as the box above mentioned, but *lacking* the cover, projecting uprights, felt edges and hole or door. In operation this box is filled with trees to within about ten or twelve inches of the top, the false bottom placed *on top* of the trees, securely fastened and the entire box inverted on level ground. One end of the box is now raised and supported by a block about a foot long. The vessel containing the acid and water is placed beneath the box, the paper bag containing the cyanide is dropped in and the block knocked from under the edge (see Fig. 5). The dirt is quickly piled around the edges of the box stopping all openings and compacted with hoe or spade. At the expiration of the required forty minutes it is only necessary to turn over the box, and after allowing to air a few minutes, remove the stock.

The boxes above described, containing 100 cubic feet, are considered by some as a little too heavy for convenient handling. A box made upon the same plan, and having the same depth and width, but being only five feet in length would contain just 50 cubic feet and the charges of chemicals therefor would be exactly one-half the charge given for the above boxes.

FUMIGATION OF BUDDING WOOD, CIONS, ETC.

Budding wood, cions, grafts, etc., can be safely fumigated before being used for propagation Only in this way can the nurseryman guard with certainty against the introduction of San Jose scale into his nursery upon the buds or cions. For fumigating peach buds, etc. the weaker strength of the gas (i. e. 2-3 oz. cyanide—with proportionate amounts of acid and water—to each 100 cubic feet) should be used, but the time of exposure should be reduced to thirty minutes.

It is often convenient to use a comparatively small box for this purpose as usually only a small bundle will be fumigated at one time. Any small AIR-TIGHT box may be used, and the amount of chemicals can be determined by multiply-

ing the number of cubic feet contained in the box by two-tenths (.2). The resulting number will be the number of grams of cyanide required. For example, a box containing 19 cubic feet would require (19 x .2)3.8 grams of cyanide of potash, with proportionate amounts of sulphuric acid and water, which in this case would be 8 cubic centimeters of acid and 16 cubic centimeters of water. The writer will take pleasure in giving the exact formula for use in a box of any size, upon receipt of its exact INSIDE measurements.

The P. J. Berckmans Co., of Augusta, Ga., have fumigated buds and grafts of various kinds for several years, in a box 3x3x3 feet, using the following formula:

Cyanide of Potash, (98 per cent) 6.75 grams,

Sulphuric Acid 9.5 cubic centimeters.

Water, 15 cubic centimeters.

Exposure to gas, 30 minutes.

It will be noticed that this formula is somewhat stronger than we recommend, yet they report that they "have never detected any injury therefrom whatever."

When fumigating buds or grafts, as when fumigating other classes of nursery stock, it must be borne in mind that the STOCK MUST NOT BE WET, that is, must not show visible moisture upon its surface.

REQUIREMENTS TO BE COMPLIED WITH WHEN SHIPPING NURSERY STOCK INTO OTHER STATES.

For convenient reference a brief summary of the requirements of other states regarding the shipment of nursery stock therein is here given. This list has been corrected by direct correspondence with the officials named and is corrected up to June 1st, 1904, except where otherwise stated. The names given are those of the officials having the inspection work in charge, or from whom additional information can be secured:

Alabama—A *signed* copy of inspection certificate must be filed with the Secretary of the Board of Horticulture, Auburn, Ala. At same time a money order should be sent for the necessary number of official tags, which are furnished at cost of printing viz: First one hundred 65 cents, each additional hundred 35 cents, or $2.25 per thousand sent by express. Each package delivered in the State must have one of these tags attached. This means that if a nursery ships a box of nursery stock to an agent each individual order must bear an official tag.—R. S. Mackintosh, State Horticulturist, Auburn, Ala.

Arizona—No law.—R. H. Forbes, Director of Exp. Station, Tucson, Ariz.

**Arkansas*—No law.—Ernest Walker, Entomologist of Experiment Station, Fayetteville, Ark.

California—All nursery stock shipped into this state shall have marked upon it in a conspicuous place and manner, the name and address of the consignee. The name of the state, country or territory where the stock was grown must also be shown. All stock is subject to inspection and disinfection after its arrival within the State. No apricot, peach or nectarine trees or cuttings, grafts, buds, etc. of the same, will be admitted when they have been in a district where rosette or yellows is known to exist.—Alexander Craw, State Horticultural Quarantine Officer, Room 11, Ferry Building, San Francisco, Cal.

Colorado—Shipments subject to inspection by county inspectors, under direction of the State Board of Horticulture, Denver, Col.

Connecticut—All nursery stock shipped into this State must bear a certificate of inspection, together with a statement that it has been fumigated.—W. E. Britton, State Entomologist, New Haven, Conn.

Delaware—The law requires that every package or car load of nursery stock coming into the state shall bear a certificate of inspection given by a recognized entomologist and stating that the stock has been examined and found to be free from dangerously injurious in-

* In the case of those states with an asterisk, our letters of inquiry have not brought any response; hence we take it for granted that no change has been made since 1903.

sect pests and plant diseases. The inspection must have been made not earlier than August 1, and the certificate is good for one year from date of inspection. The stock must also bear the certificate of the nurseryman or shipper stating that the stock has been properly fumigated with hydrocyanic acid gas. No official tags are necessary. It is not required that the certificates be filed in the office of the State Entomologist. No fees are charged outside nurserymen. All nursery stock not accompanied by a proper certificate is held up at the railway station or other transportation office and cannot be delivered until it has been examined by a state inspector. The Entomologist and Chief Inspector is Wesley Webb, Dover, Delaware.

Florida—No law.—H. A. Gossard, State Entomologist, Lake City, Fla.

Idaho—All nurserymen doing business in this state are required to furnish a Surety Company bond in the sum of $1000, conditioned upon a faithful compliance with the law. Requirements are: (1) All representatives must have a certificate showing that their firm or firms have given bonds; (2) That the stock being shipped in has been examined by a duly authorized officer, and a certificate of inspection attached to each package or shipment; (3) All trees, shrubs, plants, etc., must be true to name; (4) Any pit fruit coming from sections where peach yellows are known to exist is absolutely prohibited from entering the state. Also shipments from sections where pear blight or Oyster Shell Bark Scale is known to exist prohibited in any case.—A. McPherson, State Horticultural Inspector, Boise, Idaho.

Illinois—All nursery stock coming into the state of Illinois shall be officially inspected, and certified by a state or government inspector to be apparently free from all dangerous insects or diseases. No charge is made to outside nurserymen except for expenses of inspection in case stock is received without certificate.—S. A. Forbes, State Entomologist, Urbana, Ill.

Indiana—Every package of trees, shrubs, vines or other nursery stock shipped into this state from another state shall be plainly labeled on the outside with the name of the consignor, the name of the consignee, and a certificate bearing the current year's date, signed by a state or government inspector. showing that the contents have been examined by him, and that to the best of his knowledge and belief, such stock is free from San Jose scale or other destructive insects or fungous enemies.—James Troop, State Entomologist, LaFayette, Ind.

Iowa—Each shipment into this state must have attached to it a copy of the certificate of inspection of the state from which the ship ment is made.—H. E. Summers, State Entomologist, Ames, Iowa.

Kansas—No law.—E. A. Popenoe, Official Nursery Inspector, Manhattan, Kan.

Kentucky—A copy of the inspection certificate and also a list of the contents, should be attached to each bundle or package of nursery stock shipped into this state. To avoid possible delays, etc., a copy of the certificate should be filed with the State Entomologist.—H. Garman, State Entomologist, Lexington, Ky.

Louisiana—All nursery stock shipped into this state must be accompanied by an inspection certificate.—H. A. Morgan, State Entomologist, Box 583, Shreveport, La.

Maine—All nursery stock shipped into the state from any other state, country or province shall bear on each box or package a certificate that the contents of said box or package have been inspected by a duly authorized inspecting officer. and that said contents appear to be free from all dangerous insects or diseases. If nursery stock is brought into the state without such a certificate, the consignee shall return it to the consignor at the expense of the latter; provided, however, that any box or package bearing a certificate of fumigation, which shall be an affidavit made before a justice of the peace that all stock sold by the consignor has been fumigated in a manner approved by the state nursery inspector of the state from which said nursery stock is shipped the same may be accepted as though bearing a proper certificate of inspection.—A. W. Gilman, Com. Agr., Augusta, Maine.

Maryland—Nurserymen shipping stock into this state are required to file a copy of their certificate of the apparent freedom from injurious insects and diseases, issued by qualified state officials, in this office. Each shipment shall be plainly labeled on the outside, with the name of the consignor and the name of the consignee, and a copy of said certificate attached.—Thomas B. Symons, State Entomologist, College Park, Maryland.

Massachusetts—Copy of inspection certificate must accompany al nursery stock shipped into this state. An affidavit, executed before a justice of the peace, showing that the stock has been fumigated with hydrocyanic acid gas, using not less than two-tenths gram of potassic cyanide per cubic foot of space and exposing the stock to resulting fumes (in an air-tight compartment) for not less than forty minutes, will be accepted in lieu of an inspection certificate. The affidavit must set forth above points clearly, and a copy attached to each package, bundle or box.—H. T. Fernald, State Nursery Inspector, Amherst, Mass.

Michigan—Nurserymen who ship stock into this state upon mail orders, must fumigate the stock and place upon each package, in addition to the usual certificate of inspection, a certificate to show that it has been fumigated. Michigan nurseries and those of other states who sell stock through agents must take out a license previous to the 1st of August of each year. The license fee is $5.00 and a bond for

$1000 with two sureties must be filed. The conditions under the bond are that only stock which has been inspected and fumigated will be sold, and that a list of the customers will be furnished if requested. To avoid possible delays, etc., a copy of the inspection certificate should be filed with the State Inspector.—L. R. Taft, State Inspector of Nurseries, Agricultural College P. O. Mich.

Minnesota—Nursery stock shipped into this state must bear a copy of the inspection certificate.—F. L. Washburn, State Entomologist, St Anthony Park. Minn.

Mississippi—Importation of nursery stock and agricultural produce from boll-weevil infested districts of Texas and Louisiana prohibited unless accompanied by a certificate of an Entomologist of the U. S. Dept. of Agriculture stating that said stock is free from Mexican Boll Weevils. There are no restrictions upon the shipment of nursery stock from localities other than above stated.—Glenn W. Herrick, State Entomologist, Agricultural College, Miss.

Missouri—All nursery stock shipped into this State must bear the names and addresses of consignor and consignee, and must have a proper inspection certificate prominently attached.—Geo. B. Ellis, Sec., State Board of Agr., Columbus, Mo.

Montana—All nursery stock shipped into this state shall come through one of the designated quarantine stations, (Miles City, Billings, Dillon, Missoula, Kalispell, Great Falls or Glasgow,) and there be unpacked or unwrapped, inspected and fumigated. Inspection and fumigation of imported stock is provided for at any point of delivery, provided the importer pays all expenses thereof.—C. H. Edwards, Sec. State Board of Horticulture, Butte, Mont.

Nebraska—An inspection certificate should accompany all shipments into this state.—Lawrence Bruner, Professor of Entomology, and Acting State Entomologist, Univ. of Neb., Lincoln, Neb.

Nevada—No law.—J. E. Stubbs, Director Exp. Station, Reno, Nev.

New Hampshire—All nursery stock shipped into this state must bear a certificate of inspection upon each bundle or package. A satisfactory certificate of fumigation (see form of fumigation certificate required in Mass.) will be accepted in lieu of an inspection certificate. C. M. Weed, Entomologist, Durham, N. H.

New Jersey—Requires that every shipment of stock sent into the state be accompanied by a certificate from an official inspector, State or Station Entomologist, that the stock has been inspected where grown and has been found free from dangerously injurious insects. The certificate is not conclusive and the stock is liable to local inspection if it seems suspicious. No official tags are required; there are no fees or charges of any kind; filing of certificates is not required;

but where copies are sent to the State Entomologist at the beginning of the shipping season, shipments will pass unquestioned if the above requirements are complied with.—John B. Smith, State Entomologist, New Brunswick, N. J.

New Mexico—No law.—Luther Foster, Pres. N. Mexico Agr. College, Mesilla Park, N. Mex.

New York—A certificate of fumigation should be attached to each consignment of stock shipped into New York. In addition, all shipments into the state are inspected by New York inspectors.—Charles A. Wieting, Commissioner of Agriculture, Albany, N. Y.

North Carolina—No nurseryman can sell stock in this state unless he be in possession of a valid certificate of inspection, and every delivery of nursery stock in this State must be accompanied by a certificate tag of this sort. It is not required that nurserymen shall secure tags from us, but their own tags will answer. The Crop Pest Commission reserves the right to forbid transportation companies from delivering within the State the stock of any person, firm or corporation, if it has reason to believe that such stock is infested, or that their business is being fraudulently conducted. It is necessary that nurserymen file in this office a copy of their certificate of inspection. Circular No. 3, new series, Crop Pest Commission gives in condensed form all the information necessary for the guidance of nurserymen outside of the state, and will be sent to anyone on application.—Franklin Sherman, Jr., State Entomologist, Raleigh, N. C.

North Dakota—No law,—C. B. Waldron, Entomologist, Agricultural College, N. D.

Ohio—Nursery stock shipped into Ohio must be plainly labeled on the outside with names of consignor and consignee and must be accompanied with an official certificate of inspection or fumigation.—A. F. Burgess, Chief Inspector, Dept. of Agr., Columbus, Ohio.

Oklahoma—No law.—O. M. Morris, Horticulturist, Experiment Station, Stillwater, Okla.

Oregon—All shipments into this state are inspected at district quarantine stations or at point of destination, regardless of any certificates which may be attached thereto.—Geo. H. Lamberson, Sec. State Board of Horticulture, Portland, Ore.

Pennsylvania—Whenever any trees, shrubs, plants or vines are shipped into this state from some other state, country or province, every package thereof shall be plainly labeled on the outside with the name of the consignor, the name of the consignee, and a certificate showing that the contents have been inspected by a State or Government officer, and that the trees, vines, shrubs or plants therein contained appear free from all dangerously destructive insects.—N. B. Critchfield, Secretary of Agriculture, Harrisburg, Pa.

Rhode Island—All nursery stock shipped into this state must bear an inspection certificate. A proper fumigation certificate (see form of fumigation certificate required in Mass.) will be accepted in lieu of an inspection certificate.—Hon. John G. Clarke, Providence, R. Isl.

South Carolina—Nurserymen, residing without the state of South Carolina, but who are doing busness therein, are required to file in the office of the S. C. State Board of Entomology, Clemson College, S. C. their certificate of inspection and fumigation furnished to them by the entomologist of the state in which the stock is grown. To those who comply with above requirements, the official tags of the Board are issued, upon order, at a cost of eighty-five cents for the first one hundred, and fifteen cents for each additional one hundred.—Chas. E. Chambliss, State Entomologist, Clemson College, S. C.

South Dakota—No law.—W. A. Wheeler, State Entomologist, Brookings, S. Dak.

Tennessee—All nursery stock coming into this state must bear the tag of inspection of some reputable entomologist, either state or national. Infested stock, whether certified or not, is subject to confiscation.—Geo. W. Martin, State Entomologist, Nashville, Tenn.

Texas—No law.—E. Dwight Sanderson, State Entomologist, College Station, Texas.

Utah—All nursery stock shipped into this state must be certified to as having been properly fumigated with hydrocyanic acid gas before shipment.—Jos. H. Parry, Sec. State Board of Hort., Salt Lake City, Utah.

Vermont—No law.—Wm. Stuart, Horticulturist of State Experiment Station, Burlington, Vt.

Virginia—Nurserymen who ship stock into this state are required to send to the Auditor of Public Accounts (Richmond, Va.) a certified check for $20.00 drawn or endorsed payable to the Treasurer of Virginia. Certificates of inspection must also be filed with the State Entomologist at Blacksburg, Va., and official tags secured from him for attaching to all shipments. These requirements apply whether nurserymen sell through agents or conduct only a mail order business.—J. L. Phillips, State Entomologist, Blacksburg, Va.

Washington—All nursery stock shipped into Washington is inspected by county inspectors upon its arrival at destination.—A. Van Holderbeke, Commissioner of Horticulture, Tacoma, Wash.

West Virginia—Shipments must be accompanied by certificate of inspection and be plainly labelled with names of consignor and consignee.—J. H. Stewart, Director of Experiment Station, Morganstown, W. Va.

Wisconsin—All nursery stock shipped into this State must be accompanied by inspection certificate——E. P. Sandsten, Horticulturist, Univ. of Wis., Madison, Wis.

Wyoming—No law.—E. C. Buffum, Director Exp. Station, Laramie, Wyom.

* * * * * * * * * * * * * * * * *

Canada—All nursery stock coming into this country must be fumigated at one of the designated ports of entry by a federal official, at government expense. All nursery stock must be imported through one of the following ports of entry between the dates specified: John, N. B.; St. Johns, Que.; Niagara Falls, Ont.; Windsor, Ont. and Winnipeg, Man., between March 15th and May 15th or between October 7th and December 7th. At Vancouver, B. C. during the winter months only, between October 15th and May 1st.—James Fletcher, Dominion Entomologist, Ottawa, Can.

GEORGIA
State Board of Entomology

BULLETIN No. 12—SEPTEMBER, 1904.

The Mexican Cotton Boll Weevil

A CIRCULAR OF INFORMATION

BY

WILMON NEWELL

CAPITOL BUILDING Atlanta, Ga.

ATLANTA, GA.
E. W. ALLEN & CO.
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Georgia State Board of Entomology

ORGANIZATION.

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WILMON NEWELL, State Entomologist and Secretary of the Board, Atlanta.

R. I. SMITH, ... Assistant State Entomologist, Atlanta.

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Acknowledgments.

In the preparation of this little bulletin—which is little more than a brief compilation of facts secured through the investigations of others—the writer wishes to acknowledge his indebtedness to the following parties:

To Dr. L. O. Howard, of the Bureau of Entomology, United States Dept. of Agriculture, for the loan of the excellent cuts illustrating the greater number of insects which are commonly mistaken for the boll weevil.

To Professors W. D. Hunter and W. E. Hinds, whose careful investigations of the boll weevil and its habits have added much to our knowledge of this insect. The writer has quoted freely from Bulletin 45 of the Division of Entomology, in which the facts determined by these gentlemen are set forth.

To Professor E. Dwight Sanderson, State Entomologist of Texas, we are indebted for the use of the very excellent photographs of the boll weevil and its work, which are used to illustrate the first part of this bulletin. It is very rare that such excellent photographs, showing as these do, the various stages of an insect's development, are secured.

The writer is also under obligations to the members of the Georgia State Board of Entomology, for suggestions as to what phases of the boll weevill problem should be treated of in this bulletin, and what features would prove of most interest to our cotton planters.

GEORGIA
STATE BOARD OF ENTOMOLOGY

BULLETIN No. 12—SEPTEMBER, 1904.

The Mexican Cotton Boll Weevil.

(*Anthonomus grandis* Boh.)

There are at present but few farmers in the South who have not heard of the cotton boll weevil of Texas. It is doubtful if any insect has within recent years threatened such widespread destruction, and certain it is, that no insect problem has been more difficult of solution than the problem presented by this little weevil from Mexico. The interest manifested throughout the cotton-growing states, in the progress being made by the weevil in its spread, and in the many attempts made to combat it, is universal. Well may it be so, for since the arrival of this pest in the Texas cotton fields about twelve years ago, it has caused the

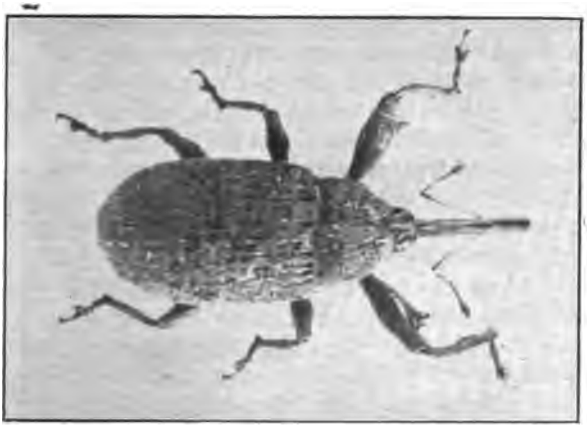

Fig. 1. Adult Cotton Boll Weevil, Much Enlarged. (After Sanderson, Proc. Second An. Session Texas Cotton Convention.)

Texas planters a loss aggregating not less than $75,000,-000. Dr. L. O. Howard, Entomologist of the United States Dept. of Agriculture, estimated the loss to the Texas cotton crop, due to this insect, at $15,000,000 for the year 1903 alone. Estimates made by cotton statisticians and by prominent Texas cotton planters placed the estimate of damage much higher than this.

So far as can be seen at present, this pest will ultimately reach all parts of the cotton belt, and estimates made by prominent authorities place the possible ultimate damage at $250,000,000.00 annually. The prospect of such a loss to the main crop of the South is appalling, and not only those directly interested in the cotton industry, but legislators as well, are giving the problem careful thought and attention. During the winter of 1903–04, the State Legislature of Mississippi appropriated $10,000 to be used in enforcing quarantine measures intended to prevent the entrance of the boll weevil into that State. The State Legislature of Louisiana, convened in special session for the purpose, appropriated $25,000 for a quarantine system against this pest, which is perhaps the most stringent quarantine ever inaugurated against any insect. The State Legislature of Georgia has not been asleep to the possible danger of introducing this insect into Georgia, and during the session of 1904 the General Assembly passed an Act including suitable quarantine measures against the introduction of this pest, and also appropriating a sum of $10,000 per annum for the use of the State Board of Entomology. While this sum of $10,000 is to be used for all the work of the Board, including inspection of nurseries, control of fruit tree insects and diseases, investigations of insects and diseases of garden and field crops, printing and distribution of bulletins upon injurious insects and methods of controlling them, etc., as much of this sum as may be necessary will be used for enforcing the quarantine measures against the boll weevil, and in preventing in every way possible the introduction of this pest into Georgia.

In addition to the appropriation of $10,000, which does not become available for use until Jan. 1st, 1905, the Legislature appropriated a special sum of $2,000.00, made im-

mediately available, in order that the quarantine might be made effective at once, that the Entomologist might take steps to determine whether the boll weevil already occurs in the State, and to disseminate information among the cotton planters regarding this insect.

A portion of this same fund of $2,000.00 is being used for an investigation of the "Black Root"* disease of cotton, and for the investigation of other cotton diseases.

The State Board of Entomology has already distributed copies of this law to all transportation companies operating in this State, has investigated a considerable number of reported occurrences of the boll weevil in Georgia, and is at present engaged in locating so far as possible all localities in Georgia to which agricultural products from Texas—especially cotton products—have been shipped within recent years. All such localities are carefully inspected to determine if the boll weevil is present. While no boll weevils have been found in Georgia up to the present time, yet it is still too early in the investigation to draw any conclusions along this line. It must be remembered that the State Entomolgist has not heretofore been furnished with any funds or means for systematically investigating the various reported occurrences of the boll weevil in Georgia, and as the average cotton planter in this State has never seen a boll weevil and would not therefore be likely to recognize it should it appear in his fields, we are not yet prepared to even guess at what may, or may not, occur in the cotton fields of Georgia.

In this work of preventing, if possible, the introduction of the boll weevil into Georgia, one of the main objects of the Board of Entomology is to thoroughly familiarize the cotton planters of the State with the appearance of this insect, its mode of attack, etc., in order that they may be on the constant lookout for it. If its first appearance can be promptly detected—and it will appear sooner or later—the chances of exterminating it, or at least of materially reducing its rate of spread, will be greatly increased. The Board must of necessity depend largely upon the hearty co-operation of the planters throughout the State if its efforts along this line are to meet with success.

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* *Neocosmospora vasinfecta* (Atk.)

The present bulletin aims to give only the main facts regarding the boll weevil problem, and by the descriptions and illustrations herein to enable the cotton planter to readily distinguish the boll weevil from all, or nearly all, of the insects resembling it. All planters should watch their cotton fields closely and carefully examine any new or unusual insects that may be found upon the cotton plants. In the case of insects which may so closely resemble the boll weevil as to make their identity uncertain, specimens should be sent to the State Entomologist, Atlanta, Ga.. *in a tightly closed tin or wooden box.* The Entomologist will at all times be glad to inform the sender of the identity of such insects.

The question of remedies are not discussed at any length in this bulletin for the reason that the pest has not yet been found in Georgia and space can be more profitably devoted to a description of the insect. When the weevil does appear, will be the time for a long and tedious discussion of the measures that have been tried against it with partial success—or as has more often been the case—with no success at all.

Historical.

Aside from its occurrence in Texas, the boll weevil occurs in Mexico and Cuba. One of these countries, probably Mexico, is undoubtedly the original home of the insect. The boll weevil was first described in 1843 from specimens obtained from Vera Cruz, and in 1871 the boll weevil was recorded as occuring at Cardenas in Cuba. The first injury to cotton by this species appears to have been in 1848 in the State of Coahuila in Mexico, although there is some little question whether the damage may not have been caused by the boll worm or the cotton caterpillar.*

In 1885 the boll weevil was received at the Dept. ot Agriculture at Washington, D. C., from northern Mexico. It made its first appearance near Brownsville, Texas, about 1892, having doubtless crossed the Rio Grande River in unginned cotton or in cotton seed. Without

* Hunter, W. D., Bulletin 45, Div. of Entomology, p. 11.

going into detail, the subsequent history of the insect's progress may be summed up by saying that it has spread

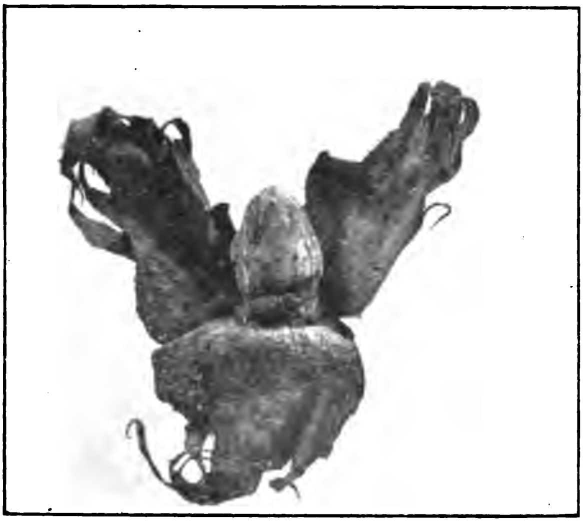

Fig. 2. Adult Boll Weevil upon a Flared Cotton Square. (From a photograph by E. Dwight Sanderson, State Entomologist of Texas.)

at the average rate of about fifty miles a year until now the infested region embraces the greater portion of the cotton-growing area of Texas, and the pest has been found in two or three localities in western Louisiana. In the case of the latter every possible means has been adopted to exterminate the pest and to prevent its further spread. The efforts of Prof. H. A. Morgan, State Entomologist of Louisiana, along this line, have been attended with remarkable success and in several instances it appears that the insect has actually been exterminated in the case of several limited infestations.

Description of the Boll Weevil.

The Adult Weevil.

The adult boll weevil is a brownish beetle varying in length from one-eighth to five-sixteenths of an inch, and measuring usually slightly over one-sixteenth of an inch

across the body at the widest part. The weevil is provided with a long "snout" or "proboscis" and is not unlike the common acorn weevil in appearance. It is not by any means a far-distant relative of the chestnut weevil, the

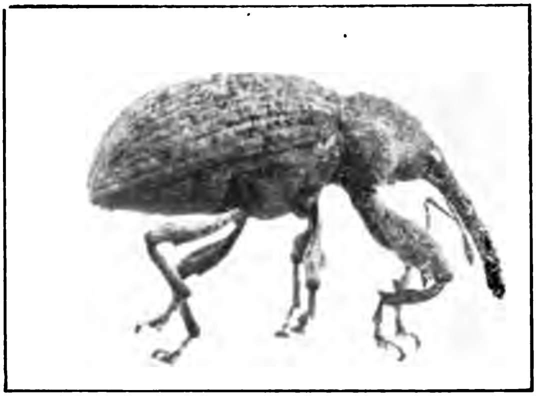

Fig. 3. Side View of an Adult Boll Weevil, Much Enlarged. (After a photograph by E. Dwight Sanderson.)

plum curculio and a number of other common weevils with which almost everyone is familiar. The adult boll weevils vary considerably in size as is shown in Figure 4. In color the boll weevils vary from a light gray to a

Fig. 4. A Series of Adult Boll Weevils, showing Variation in Size. (After Sanderson, Proc. Second An. Session Tex. Cotton Conv.)

dark chocolate brown or black. As a usual thing, the older the weevil the darker in color it becomes, owing to the minute hairs or scales wearing off the body-surface. Under an ordinary magnifying glass the weevil is seen to be covered with minute scales, closely resembling hairs.

These hair-like scales are clearly shown in Figure 3. The "elytra" or wing-covers (in the case of beetles what appear to be the forewings are in reality developments of the chitinous body-covering which cover the true wings, but these "elytra" are not used in flight) are also seen to be finely lined, the fine lines or ridges running lengthwise of the body. By far the most reliable character in distinguishing a boll weevil from other similar weevils is the presence of two small spines upon the interior of the femur ("upper joint") of the fore-leg. One of these spines is considerably larger than the other. These two spines are not found upon the fore-legs of any other of our common weevils although the occurence of a single spine is common to many different weevils.

The adult boll weevils pass the winter in trash, rubbish, grass, old cotton bolls, and similar material about the infested fields, and also in the leaves and trash of timber lands. These hibernating weevils leave such quarters in the spring, at about the time the first cotton is above ground and beginning to form squares, and having fasted since the previous autumn, begin to feed to a considerable extent upon the tender buds and stems of the young cotton plants. As noted above, the weevil has a long beak, at the end of which is a pair of small but very strong mandibles. With these mandibles the outer layer of the cotton bud or square is torn off, the beak inserted into the softer tissue beneath and this latter actually consumed.

Fig. 5. Cotton Square howing Feeding Punctures made by Boll Weevil. (After a photo by E. Dwight Sanderson.)

A square showing a number of feeding punctures made by the weevils is seen in Figure 5. Punctures are made in a similar way by the females in which to deposit eggs, as well as for feeding, but according to Prof. W. D. Hunter, the punctures made for feeding are usually much larger and deeper than those made for receiving the eggs.*

* *Loc. cit.* p. 38

The Egg.

The egg of the boll weevil is described by Prof. W. E. Hinds as being pearly white in color, elliptical in form, and about .8 mm. (approximately one-thirtieth of an inch) in length by .5 mm. wide.* The egg is deposited by the female weevil in punctures made in squares or bolls for that purpose. Within the square or boll the egg is well protected from parasites and other enemies. An egg is shown among the anthers in an unopened square in Fig. 6, the position of the egg being indicated by the arrow.

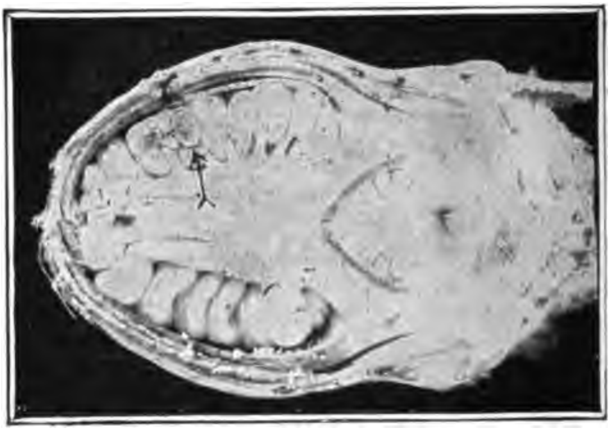

Fig. 6. Unopened Cotton Bloom, Showing Egg of Boll Weevil among the Anthers, Much Enlarged. (After Sanderson, Proc. Sec. An. Ses. Tex. Cot. Conv.)

The duration of the egg stage varies with the temperature and the time of season. Messrs. Hunter and Hinds have found that during September the egg stage, from time of deposition to hatching, lasts from 2½ to 3 days, but that in November when the weather is cooler the egg stage averages from 3½ to 4 days.† As a rule the females deposit only one egg in a square or form and more than one is rarely deposited in the same square unless, as is the case during middle and late summer, squares are not produced upon the plants fast enough to accommodate the many females then in the fields. In such cases the eggs are frequently deposited in the young bolls and sometimes

* Hinds, W. E., Bul. 45, Division of Entomology, p. 20.

† *Loc. cit.* p. 21.

more than one egg is deposited in a single square. As long as there are plenty of uninfested squares in the cotton field there is little or no egg deposition in the bolls. Owing to the difficulties of observation, it is hard to say just what is the general average number of eggs deposited by each female, but Professor W. E. Hinds made careful and accurate observations upon several females, all of which deposited over 225 eggs each.†

The Larva.

Fig. 7. Larva or Grub of Boll Weevil, Much Enlarged. (After Sanderson, Proc. Sec. Ann. Ses. Tex. Cot. Conv.)

The larva which hatches from the egg within the square or boll, is a white footless "grub" with a brownish colored head and a pair of very substantial mandibles, with which it proceeds to feed upon the tissue surrounding it. The entire larval stage is passed within the square, form or boll in which the egg is deposited, as is also the next or pupal stage. The larva enlarges rapidly after hatching from the egg and by the time it has reached maturity has eaten the greater part of the contents of the average-sized square. During mid-summer the larval stage varies from 6 to 8 days, while in early summer and in autumn it is longer. Prof. Hunter found that during November and December the larval stage averaged from 20 to 30 days.

One of the first indications of infestation by boll weevil is the flaring of the involucre or "shuck" surrounding the square. This opening of the involucre takes place usually a short time after the larva hatches from the egg and a few days later the infested square is shed by the plant. A characteristic flared square is shown in Fig. 2 and also in Figure 12. The presence of boll weevils in

†Bul. 45, Div. of Entomology, p. 58.

any considerable numbers in a cotton field is always accompanied by a profuse shedding of squares. However the latter are often shed on account of certain weather

Fig. 8. Boll Weevil Larvae within Cotton Squares. (After a photo by E. Dwight Sanderson.)

conditions, but in this case no insects or larvae are likely to be found within them if they are examined soon after falling. Injury from almost any cause will result in the shedding of squares, and squares which have been eaten

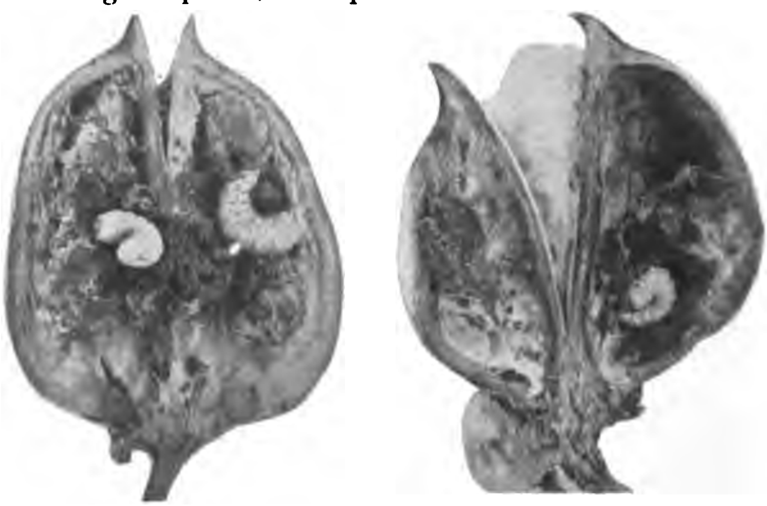

Fig. 9. Boll Weevil Larvae within Cotton Bolls. (After a photo by E. Dwight Sanderson.)

into by the boll worm (not boll weevil) are of course shed by the plants. (See Figure 21.) The presence of white larvae within shed squares or forms should be regarded with suspicion and all such should be carefully examined. In cotton fields badly infested by the boll weevil the feeding punctures and the punctures made for egg deposition cause the squares to shed as fast as formed and before they have any opportunity to develop into bolls.

The Pupa.

Fig. 10. Pupae of Mexican Boll Weevil. (After Sanderson, Proc. Sec. An. Ses Tex. Cot. Conv.)

Fig. 11. Boll Weevils Within Cotton Squares, Ready to Emerge. (After a photo by E. Dwight Sanderson.)

When the larva has completed its growth it ceases to feed, becomes shorter and broader and enters the "pupal stage," during which it takes no food.

The future proboscis, legs and other parts now begin to appear. The pupae are well illustrated in Fig. 10. This stage lasts from 3 to 6 days in mid-summer and is longer at the approach of cold weather. The pupa changes in-

Fig. 12. Adult Boll Weevil Emerging from Square within which it Developed. (After a photo by E. Dwight Sanderson.)

to the adult boll weevil, which emerges from the square or boll (See Figure 12) and although light in color and soft-bodied upon emergence from the square, it soon becomes darker, the body-covering hardens and the weevil takes its first meal as a fitting celebration of its safe arrival at maturity.

Rate of Increase and Destructiveness.

From the foregoing it will be seen that during midsummer the time elapsing between egg deposition and the arrival of the weevils at the adult stage may vary from 12 to 18 days. If an average allowance of 6 days be made for the time elapsing between emergence and the beginning of egg deposition by the adult, a generation may be produced every 18 to 30 days. During late autumn the period of development is of course much lengthened. Upon

facts obtained by actual observation in the infested cotton fields of Texas, Prof. W. D. Hunter estimates that the progeny of a single pair of boll weevils may in a season reach 134 millions of individuals.*

As each female during her lifetime deposits eggs in each of from 100 to 200 squares, all of which are prevented from making bolls, the magnitude of the destruction will be readily understood.

At the approach of frost in the autumn, the adult weevils seek suitable quarters in which to pass the winter. For the most part rubbish about the cotton fields, leaves in timber lands, grass, partially opened bolls etc., are selected. In the case of baled cotton which is lying on the

Fig. 18 Cotton Squares from which Boll Weevils have Emerged after Reaching the Adult Stage. (From a photograph by E. Dwight Sanderson.)

ground about gin houses during the autumn, boll weevils are likely to enter the bagging, and if the bale is subsequently moved to other localities the hibernating weevils may be carried with it. During autumn there is also a possibility of weevils, which are seeking hibernating quarters, entering bales of hay, straw, etc., in the infested region. During the hibernating period the boll weevil is in a semi-dormant condition in which it can sur-

*Yearbook, U. S. Dept. of Agriculture, 1903, p. 205.

vive for several months without any food, and during this time it is possible for it to be transported many miles to new or uninfested localities. In the weevil-infested sections of Texas, boll weevils are found abundant in the cotton seed at gin houses, as well as in cotton seed hulls. As would naturally be expected, the shipment of these cotton products is often found to be the means of distributing the boll weevil to new localities.

There is a possibilty, and even probability, of the weevil being transported in baled hay, straw, etc., when the latter is shipped from the infested section during the fall, winter, or early spring. During the summer months there is practically no danger of the weevils being transported in hay, straw, etc., as at that season the boll weevils are seeking the growing cotton in cotton fields, and have no occasion whatever to enter hay, rubbish, etc.

Skilled entomologists who have carefully studied the boll weevil problem are agreed that there is practically no danger of transporting the weevil in shipments of seed oats, thrashed wheat, etc., during July, August and September, as these grains are harvested at a season when the weevils are in the cotton fields and are not seeking hibernating quarters. In any event, thrashed grain would not offer suitable hibernating quarters for the weevil, and the writer questions whether boll weevils would voluntarily enter thrashed grain for the purpose of hibernating, even were it readily accessible to them.

Remedies.

As intimated on a former page of this article, it is not our intention to discuss remedies at this point, as this subject can best be left until the boll weevil is actually discovered in Georgia, and by that time (let us hope) there may be more efficient remedies at hand than are known today. To sum up briefly the remedial measures as practiced and advocated by the U. S. Dept. of Agriculture, we may say that the production of cotton in the weevil-infested sections is dependent upon using an early-maturing variety, planting it early and cultivating it thoroughly so as to force it to an early maturity. By this plan a

considerable number of bolls are set upon the plants before the weevils become abundant enough by July 15th or August 1st to destroy all squares as fast as they are formed. In this way a "profit-returning" crop of cotton can be made in spite of the weevil, but if the same improved methods of culture and improved varieties were used under the same conditions without the weevil being present, doubtless from 25 to 50 per cent more cotton would be made. In any event, and under any devisable system of cultivation the advent of the boll weevil must bring with it an actual and heavy loss.

The Relation of Birds to the Boll Weevil Problem.

While the entomologist is trying in every way possible to prevent the introduction of the boll weevil into Georgia, it also behooves the planter himself to do something in anticipation of the problem which he will sooner or later have to confront. It may be one year, or it may be twenty, before the boll weevil appears in Georgia, but if any measures can be taken now, by which the ravages of this insect can be lessened when it does appear, the resulting good to the cotton interests of the State could hardly be overestimated. Such precautions lie within the reach of the Georgia farmers. While without doubt, many birds feed to a greater or less extent upon boll weevils, there are two species at least that are of incalculable value in this respect. These are the common partridge or Bobwhite* and the field lark.† The partridge or quail is a feeder upon both vegetable and animal matter. While weed seeds and grains make up the bulk of its food in winter, during the summer its food consists mainly of insects. Among these insects is included the boll weevil. Dr. Judd records an instance of a quail having eaten 47 boll weevils during a single morning,‡ this fact being determined by an examination of the bird's stomach after being shot. The quails are with us during the entire year and while the most good would

* *Colinus virginianus.*

† *Sturnella magna.*

‡ **Yearbook U. S. Dept. of Agriculture, 1903, p. 196.**

be expected from them during the summer when the weevils are active, still it is not at all unlikely that they obtain many of the hibernating weevils during the winter, when the birds are constantly engaged in scratching up leaves, trash, etc., in their search for food.

In the case of the field lark, the writer while in Texas during 1902, knew of a case where the stomachs of field larks, shot in a cotton field, were examined. In the stomach of one field lark the remains of 27 boll weevils were found and in the stomach of another 14 were found. It is true that the field lark is rarely with us during the entire year, but it is usually abundant in spring when the boll weevils would be emerging from winter quarters and again in the fall and winter when the weevils are in hibernating quarters. The field lark is mainly a ground feeder, searching over meadows and fields for its food and without doubt many boll weevils are destroyed by it in the weevil-infested sections.

The benefits derived from these birds—so far as the boll weevil problem is concerned—will depend entirely upon their abundance, and if they are plentiful when the boll weevil reaches Georgia the ravages of the latter will be lessened considerably. Natural enemies of the boll weevil are scarce, and when an opportunity thus presents itself for allowing two of the weevil's natural enemies to increase before the weevil arrives, it should not be neglected. We do not hesitate to say that the killing of partridges and field larks in Georgia should be absolutely prohibited by legislative action at once, and that competent game wardens should be provided to see that such a law is strictly complied with. We are well aware that such a proposed action upon the part of the Legislature would be vigorously opposed by sportsmen and perhaps by some farmers, but should the interests of the cotton industry be jeopardized in order to furnish pleasure and recreation for a select few? The farmer, even under the existing law, can prevent the killing of birds upon his premises. The question is, will the farmer open his eyes to his own interests and proceed to prevent the destruction of quails and field larks upon his plantation, in order that they may increase to the point of abundance where they will render him most valuable service?

Unless the farmer does protect these birds, the day will come when he will regret that he has not done so, and it may not be at all surprising if that regret is made all the more intense by the knowledge that his cotton crop is being materially reduced by the attacks of the boll weevil.

Insects Frequently Mistaken for the Boll Weevil.

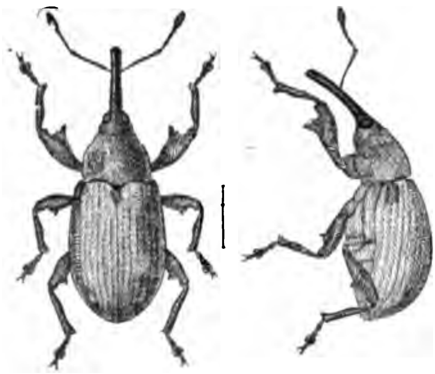

Fig. 14. Mexican Cotton Boll Weevil, *Anthonomous grandis*, Boh. (After Hunter, Bul. 45, Div. of Ent., U. S. Dept. of Agr.)

Many Georgia cotton planters, with commendable zeal, have closely observed the insects occuring in their cotton fields within the past year, and as a result have discovered many kinds of insects the existence of which was previously unknown to them. Many of these have been mistaken for boll weevils. In order to assist the farmer in recognizing the more common of these, a number of species are illustrated on the following pages, and the differences by which they are distinguished from the boll weevil, pointed out. In most cases the illustrations will make this difference clear, without any added description. All of the insects mentioned have been sent to the Entomologist within the past few months, the senders believing them to be boll weevils. For convenient comparison the genuine boll weevil is shown in Figure 14.*

The Cowpea-pod Weevil.

(*Chalcodermus aeneus* Boh.)

This little beetle, which is supposed to breed in the pods of cowpeas, is about the same size as the boll weevil, but is a jet black color. The body-surface is smooth shining black, and instead of the wing-covers being finely lined as in the case of the boll weevil, both elytra and thorax are covered with minute impressions.

* The drawings of this and other insects upon subsequent pages, are much enlarged. The single black line at the side of each drawing is, however, the same length as the specimen from which the drawing was made.

The use of an ordinary hand magnifying glass will readily distinguish this weevil from the boll weevil. Where cotton follows cowpeas the adult cowpea-pod weevils sometimes attack the young cotton plants soon after they come up, and do considerable damage.

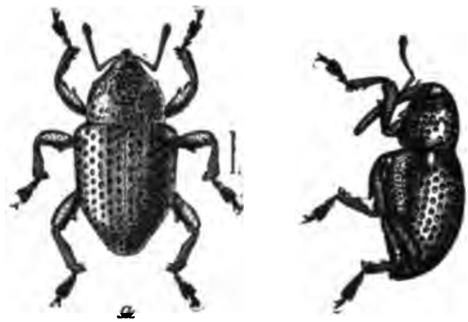

Fig. 15. Cowpea-pod Weevil. (After Chittenden, Bul. 45, Div. of Ent, U. S. Dept. of Agr.)

The Acorn and Chestnut Weevils.

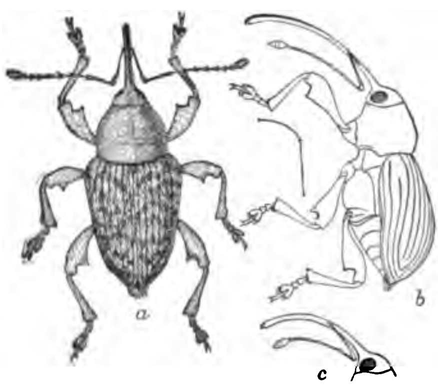

Fig. 16. Acorn Weevil, *Balaninus victoriensis* Chit. (After Chittenden, Bul. 44, Div. of Ent., U. S. Dept. of Agr.)

The acorn weevil, the chestnut weevil, and other nut-feeding weevils, all of which closely resemble each other, are discovered from time to time upon cotton plants. It is extremely likely that their occurence upon cotton is purely accidental, as when cotton is growing near or under chestnut or oak trees. In any event, no damage to cotton need be apprehended from them. A weevil which is typical of the appearance of this group of insects is shown in Figure 16.

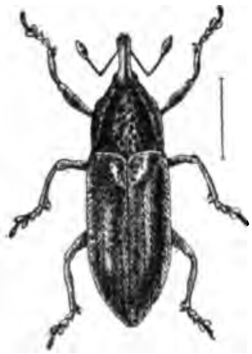

Fig. 17. Blood-weed Weevil, *Lixus* sp. (After Hunter, Bul. 45, Div. of Ent., U. S. Dept. of Agr.)

The Blood-weed Weevils.

During the winter a careful examination of the stems of ragweed or blood-weed about almost any field will reveal the presence of long slim weevils in the pith or interior of the stalks. These are the blood-weed weevils, of which there are several species. They are readily distinguished from the boll weevil by the fact that they are long and slim, as shown in the illustration (Figure 17.) The majority of these blood-weed weevils are one-half inch or more in length while the boll weevil is ordinarily about one-fourth inch in length and of an entirely different shape.

Other Snout Beetles.

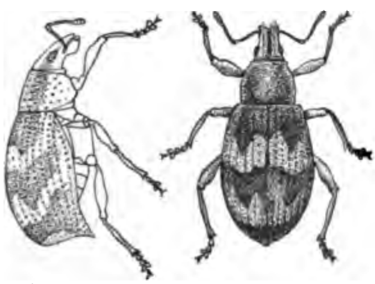

Fig. 18. Imbricated Snout Beetle, *Epicaerus imbricatus* Say. (After Chittenden, Bul. 45, Div of Ent., U. S. Dept. of Agr.)

The plum gouger, Fuller's rose beetle, the imbricated snout beetle and even so common an insect as the plum curculio have been mistaken for boll weevils. None of these feed upon cotton and when found upon cotton plants or among cotton seed their occurence in such places must be considered as accidental. The imbricated snout beetle is shown in Figure 18.

Click Beetles.

Fig. 19. Click Beetle, *Monocrepidius vespertinus*. (From Chittenden, Bul. 45, Div of Ent., U. S. Dept. of Agr.)

Every country schoolboy is acquainted with the long, flattened snapping beetles, which when laid upon their backs, "snap" violently into the air. During mid-summer these snapping beetles are occasionally found in cotton bolls which have been injured by the boll worm. They seem to be present for the purpose of feeding on the decaying tissue and exudations following the attacks of the boll worm. We think it extremely improbable that they

are responsible for any damage to cotton, as we have never learned of their attacking healthy bolls or squares. Their shape, as well as their habit of "snapping," when laid upon their backs upon a level surface, will readily enable anyone to distinguish them from the boll weevil.

The Cotton Sharpshooter.

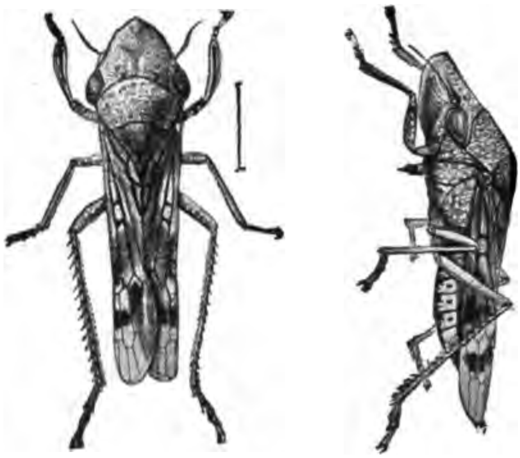

Fig. 20. Cotton Sharpshooter, *Homalodisca triquetra* (After Riley & Howard in Insect Life.)

It seems strange that an insect which is not a weevil at all or which is not even a beetle, should be mistaken for a boll weevil.

The cotton sharp shooter, shown in Figure 20, is about one-half inch in length and is not infrequently found upon cotton, which it injures by puncturing both the young growth and the squares and forms. The insect is very agile, running to the opposite side of the cotton stem when approached, and flies readily. It is not easily captured, and this fact alone will always relieve the planter's mind of any fear that it may be a boll weevil. Ordinarily the real boll weevils can be picked from the plants or squares without any precaution being taken to avoid their escape.

The Cotton Boll Worm.
(*Heliothis armiger.*)

There is a tendency on the part of some persons, not familiar with insects, to confuse the names "boll weevil" and "boll worm," believing that these terms apply to one and the same insect. As a matter of fact they are entirely distinct and separate insects belonging to two widely separated Orders or groups.

The parent of the boll worm is a moth, not likely to be taken for a boll weevil by even the most unobserving. The attacks of the boll worm larvae upon the cotton squares or bolls often give rise to reported occurences of the boll weevil. The attack of the nearly-grown boll

Fig. 21. Cotton Squares Injured by Boll Worm Larvae. (Photo by R. I. Smith.)

worm upon the bolls, takes the form of distinct holes, which are about one-fourth of an inch in diameter, made usually in the base or side of the boll. No such injury as this is ever made by a boll weevil. The holes eaten into squares by the very young boll worms may, however, be confused with the holes made in squares by adult boll weevils when the latter emerge. Squares injured by

young boll worms are shown in Figure 21. In the case of injury ot this kind, a careful search will usually reveal the young boll worm in the act of eating into the square, or even eating within it. The boll worm larva is readily separated from the boll weevil larva. The young boll worm is supplied with legs whereas the boll weevil larva is a footless grub, white in color, and incapable of crawling from square to square as the young boll worms do.

The Georgia Boll Weevil Quarantine Law.

The following Sections from an Act of the General Assembly of the State of Georgia, approved Aug. 15th, 1904, are given for the information of transportation companies, planters and others interested.

SECTION 15.—It shall be unlawful for any person to knowingly bring into the State of Georgia any living Mexican Boll Weevil, or any cotton bolls, squares, plants or seeds containing the adult, pupal, larval or egg stage of said Mexican Boll Weevil unless the person shall immediately upon its discovery at once destroy the same or turn over the same to the State Entomologist. Violation of this Section shall be punished as provided by Section 1039 of the Penal Code of Georgia of 1895.

SECTION 16.—No cotton seed, seed cotton, cotton seed hulls or cotton lint, in bales or loose shall be brought into this State from any points in the States of Texas and Louisiana, or from any other point in any other State or country wherein the Mexican Boll Weevil is known to exist, without having attached thereto in a prominent and conspicuous manner, a certificate signed by a duly authorized State or Governmental Entomologist stating that said cotton seed, seed cotton, cottonseed hulls or cotton lint, was grown in, and that the shipment of same originated in, a locality where by actual inspection by said official or his agent, the Mexican Boll Weevil was not found to exist. Any Steamship, Railroad or Express Company or other common carrier, or any firm, person or corporation bringing into this State any of the articles above mentioned, without the specified certificate attached, shall be deemed guilty of a misdemeanor. In case any common carrier enumerated violates this Section then the General Manager of such Common Carrier or the Captain of such offending vessel shall be deemed guilty and upon conviction shall be punished as provided by Section 1039 of the Penal Code of Georgia of 1895.

SECTION 17.—No oats, hay, fodder, husks, straw, forage of any kind, corn in the husk, or shipments of nursery stock, furniture, glassware, machinery or supplies of any description which are packed or partially packed in or with straw, hay, husks, grass, leaves, moss or other material originating upon farms or plantations, shall be shipped into this State from points in Texas and Louisiana or any other State or Country in which the Mexican Boll Weevil is known to exist, without having attached thereto in a conspicuous manner the certificate provided for in Section 16.

SECTION 18.—Transportation Companies shall immediately notify the State Entomologist (Atlanta, Ga.,) when by oversight, negligence or otherwise, any shipments of the nature designated in Sections 16 and 17, without a proper certificate attached, shall arrive at any station or wharf in this State, and it shall be his duty to proceed as speedily as possible, by himself or assistant to investigate such shipment. If upon investigation, he find the shipment to be of the nature herein designated he shall order same removed from this State. Upon failure of the owner or shipper to remove same within forty-eight hours after notice has been sent him by wire, said shipment shall be seized and burned.

SECTION 19.—The State Entomologist and his assistants shall have authority to enter, during reasonable business hours, any depot, warehouse, freight, wharf, transfer, steamship or express office in this state and shall be allowed full access to all way-bills, invoices and bills of lading therein, when he or they may deem it necessary to determine the presence or record of any shipments of the nature designated in Sections 16 and 17 of this Act. The State Entomologist and his assistants shall have authority to enter at any time, for the purpose of inspecting shipments therein, or for determining the nature of shipments therein, any express car or steamship when same is in transit or lying at dock or depot in charge of any employee or official of the company owning or operating same. Agents and employees of railroads shall be required to open for inspection any car, sealed or unsealed, at any siding, freight yard or depot in this State, when so ordered by the State Entomologist or his assistant. Any person who shall refuse to comply with the instructions of the State Entomologist or his assistants as herein specified, or who shall offer any hindrance or shall obstruct the State Entomologist or his assistants in the discharge of their duties as herein specified shall be deemed guilty of a misdemeanor, and upon conviction shall be punished as provided by Section 1039 of the Penal Code of Georgia of 1895.

SECTION 20.—The State Entomologist, himself or assistants, shall have power to enter during ordinary business hours any premises, depot, warehouse, cotton mill, oil mill, or other building or place in this state where agricultural products are or are supposed to be, for the purpose of inspecting and determining whether any boll weevils are there present. In case of finding any material therein infested with the Boll Weevil he shall at once give instructions to the owner, agent or tenant thereof, to destroy, fumigate or treat such infested material in such manner as in his judgment he may deem best. But in the event said material should be ordered destroyed the owner shall be compensated as now provided by law in cases where property is condemned for public use. Failure of the agent, owner or tenant to comply with said directions (unless an appeal be taken as provided for in Section 4 of this Act), or the removal of said infested material or any part thereof from the premises shall be deemed a misdemeanor and shall be punished as provided by Section 1039 of the Penal Code of Georgia of 1895.

GEORGIA
State Board of Entomology

BULLETIN No. 13—OCTOBER, 1904

Some Common Insects Injurious to the Apple

BY

R. I. SMITH.

CAPITOL BUILDING ☙ Atlanta, Ga.

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Georgia State Board of Entomology

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Fig. 1

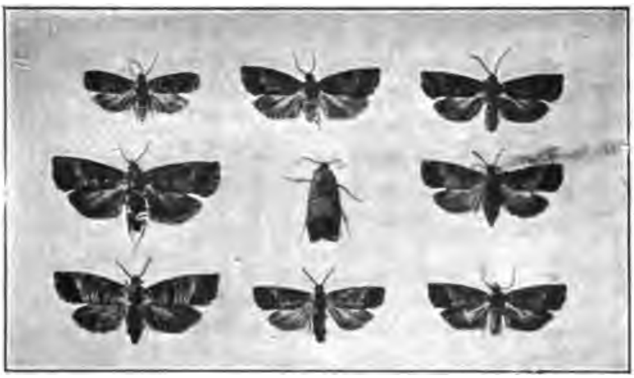

Fig. 2

Fig. 3

Fig. 1—Codling moth, enlarged 4 times. (After Simpson, Bul. 4 1, Div. of Ent. U. S. Dept. of Agriculture.)

Fig. 2—Codling moths, natural size. (After Slingerland, Bul. 142, Cornell University Exp. Station.)

Fig. 3—Codling moth larva or "apple worm", enlarged about 3 times. (After Simpson, Bul. 41, Div. of Ent., U. S. Dept. of Agriculture.)

BULLETIN

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GEORGIA STATE BOARD OF ENTOMOLOGY.

OCTOBER, 1904. *No. 13.*

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SOME COMMON INSECTS INJURIOUS TO THE APPLE.

R. I. SMITH.

Apple growing in Georgia at present constitutes but a small part of the State's fruit industry. Other fruits, such as peach, plum, pear, etc., have been considered as more profitable and as better adapted to the climate. In South Georgia we find only a few apple trees planted, these being mostly in family orchards for home use or for the strictly local market. In Middle Georgia apples are grown somewhat more extensively, while in North Georgia an apple orchard of commercial importance is not uncommonly met with.

Almost everyone having a family orchard attempts to grow a few varieties of apples, and in fact, such an orchard would not be by any means complete without this delicious and appetizing fruit. Hence it may not be out of place to describe in this short paper a few of the insects which annually interfere with successful and profitable apple production in Georgia.

The fact that one may see standing in various parts of Middle and North Georgia, apple trees so old that the oldest inhabitant does not know when they were planted, indicates that the apple is well adapted to this climate and that with proper care it could be developed into a most important part of Georgia's fruit industry.

The commercial apple grower will find that his trees must be

protected from insects and disease, and that they will need fully as much care in this regard as any other class of fruit. Those who grow apples merely for the table will also find much satisfaction in harvesting the clean, healthy fruit which results from proper treatment for, and preventive measures against, the insects that assail the apple each season.

The complete list of insects which at times attack the apple is a very long one, including upwards of a hundred different species. In this paper only four of the most injurious will be considered, not only because mention of more would occupy too much space, but because the ones herein mentioned are of most common occurrence and for the most part are readily recognized by the fruit growers.

THE WOOLY APHIS.

(Schizoneura lanigera.)

This little insect belongs to the same family as the plant lice which infest the buds and leaves of the apple during the early summer, and differs from the latter mainly in that it secretes a white cottony substance about its body and infests, as a rule, the roots of the trees. Where trees are infested when they come from the nursery they are likely to be found seriously injured in from two to four years after planting. Its presence on the root is indicated by cottony masses, under which, by a close examination, may be detected the brownish-pink bodies of the lice. By feeding upon the roots these lice cause abnormal swellings or galls the tissue of which soon dies, and the roots are destroyed. The main support of the tree being thus impaired, a high wind soon topples it over. The root-infesting form of the wooly aphis is shown in Figure 5.

Besides the root-infesting form, there is an "aerial" form (See Figure 4) which attacks the trunk and limbs but the injury from this form is not great. This form feeds mostly in cracks, old cuts or bruised places in the bark and its presence is readily detected by the white cottony appearance of the colonies. The damage done by this form is little more than a killing of the bark at the point

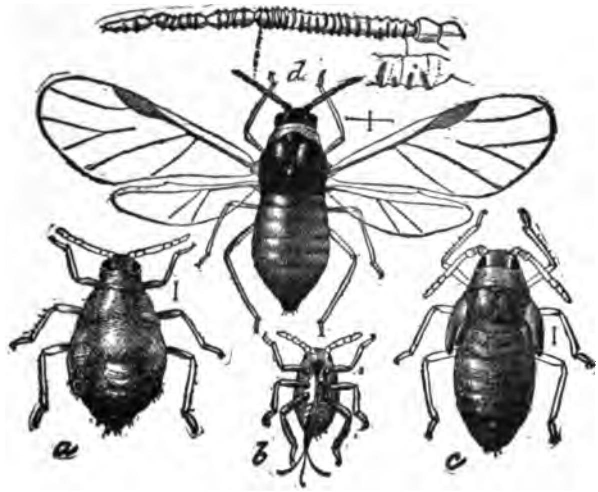

Fig. 4—Wooly aphis (*Schizoneura lanigera*). *a*, Agamic female; *b*, larva louse; *c*, pupa; *d*, winged female with antenna enlarged above; all greatly enlarged and with waxy excretion removed. (Marlatt, Circ No. 20, sec. s., Div. of Ent., U. S. Dept. of Agr.)

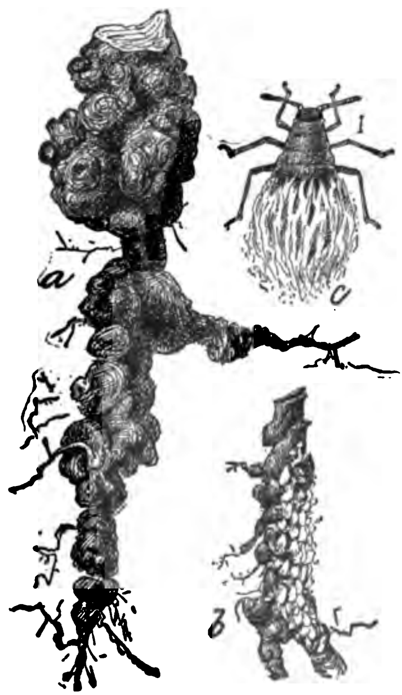

Fig. 5—Wooly aphis (*Schizoneura lanigera*). *a*, Root of young tree illustrating deformation; *b*, section of root with aphids clustered over it; *c*, root louse, female—*a* and *b*, natural size; *c*, much enlarged. (Marlatt, Circ. No. 20, sec. s., Div. of Ent., U. S. Dept. of Agr.)

of attack. The aerial form is readily killed by spraying thoroughly with a whale oil soap solution made of one pound of whale oil soap to each gallon of water; with kerosene emulsion, or with some tobacco solution such as diluted Rose Leaf Tobacco Extract. A home-made tobacco decoction is easily prepared by boiling three pounds of tobacco stems in five gallons of water for three hours, adding water from time to time to make up for evaporation. These colonies on trunk and limbs must be thoroughly drenched with whatever insecticide is used, as the cottony covering protects them effectually from any light application. We consider the aerial form more of an advantage than otherwise, as it serves to give the orchardist warning of the more serious injury that is likely occurring on the roots of the trees at the same time.

An apple tree having the roots infested with wooly aphis usually presents a sickly appearance, with a yellowish foliage and a noticeable scarcity of healthy leaves. Examination of the roots will usually disclose the "aphis galls" in such cases.

As the root-infesting form of this insect is the most injurious, it is important that the main remedial measures should be directed against it. The remedy is easy to apply, but its efficiency depends upon its use when the aphis first appears and while the trees are young. Tobacco dust is an effective remedy and has been used with most gratifying success in Ohio. *

In applying this to four or five-year-old apple trees, remove the soil for about two or three feet on each side of the tree, and to a depth of three or four inches. Into this opening sprinkle about five pounds of tobacco dust and replace the dirt. Larger quantities should of course be used upon older and larger trees. Other remedies, such as boiling water, potash soap, ashes, etc., have been tried but always with little or no success. The tobacco dust remedy should be applied in the spring as soon as the ground is "settled," and its thorough success will depend upon its application before the trees get old and become badly infested.

APPLE TREE BORERS.

(Saperda candida and *Chrysobothris femorata.)*

A common injury to apple trees is that caused by borers in the main trunk near or just above the surface of the ground. There

*Stedman, J. M., Western Friut Grower. April, 1904.

are two borers which may cause serious damage, known as the round-headed and the flat-headed. These names are descriptive of the larvae of these two different insects, and, as they imply, the one is nearly cylindrical in form, with a head about the same size as the body, while the other has a flattened head, which is very broad as compared with the width of the body. There is also a marked difference in the life-history of the two insects.

The adult round-headed borer is a beautiful beetle, about three-fourths of an inch in length, of a pale, brownish-yellow color above and having two broad, creamy-white stripes running the entire length of the body. These beetles appear during May and June and the females soon thereafter commence to deposit their eggs in cracks or crevices in the bark near the base of the tree. The egg hatches in about two weeks into a minute worm which immediately bores through the bark and commences to feed on the sap-wood. For the first year, the larvae confine their attacks to the sap-wood, making a disc-shaped burrow about the size of a silver dollar. Unless several are present the injury is not likely to be very noticeable the first season. At the close of the first season the larva or borer, which is as yet but partly grown, goes to the lowest part of the burrow and there remains quietly through the winter. The second year of the borer's life is also passed in the sap-wood but it no longer confines itself to a small area, but may work around a small tree, completely girdling it. When more than one borer is present in a young tree this is often the case. The second winter is also passed in the lowest part of the burrow. The third season of the borer's life finds him boring into the heart of the tree, and in the case of a small tree the channel may extend nearly or quite to the opposite side of the trunk.

The borer attains its full development the third summer and after boring into the heart of the tree the channel through which it entered is closed with sawdust-like castings and another opening is made through which the adult beetle may escape the following spring. In this latter channel the larva passes the third and last winter of its life, and in spring the complete change to the adult

takes place, and there emerges the beautiful beetle already described.

When a borer is discovered in a tree, the only remedy is to dig him out with a sharp knife. This can best be done in August and September. Knowing the life-history, it is evident that borers should be removed every year, in order to get them while still in their first season's development. If a borer has gone into the heart of the tree a sharp wire may be thrust into the opening and twisted about to kill the borer, even though he may not be entirely removed.

When looking for borers, a sharp lookout should be kept for discolored patches of bark, which, when pressed with the finger, give way and indicate the hollow underneath. Oftentimes the presence of a borer is indicated by an exudation of sap together with some of the sawdust intermingled. The sap, or gum, however, does not often come out in great quantities as it does upon peach trees which are attacked by the peach tree borer.

In addition to apple trees, the round-headed borer may attack quince, Juneberry, native crab apple, ash and possibly other trees.

The adult flat-headed borer is a beetle about one-half inch in length, with a flattened, oblong body, tapering toward the posterior end. The color is greenish-black, with bronzy reflections, while the legs shine like burnished gold. The feet are shining green in color. As to the life-history of the flat-headed borer, but little need be said except that it is supposed to complete its transformations — from egg to adult — in a single year. From eggs that are laid this summer, adult beetles will develop next summer. The remedy is the same as for the round-headed borer and should be attended to at the same time, namely, during August and September.

Aside from the knife remedy, the trees may be protected by a coat of whitewash or a thick alkali soap solution. A still better plan is to wrap the trees, to a height of about eighteen inches, with thick brown paper tied firmly and pressed into the cracks so that no insect can crawl underneath it. Dirt should be piled around the lower end of this band. Whitewash or the soap solution may be applied above the band, but whatever is used for a protec-

tion should be applied as early as May 1st to be thoroughly effective. It is also advisable to repeat this application about June 1st, especially if there have been heavy rains. When paper is used this latter should be removed after the first of August. All these exterior coverings and applications of whitewash serve only to discourage the adult beetles from depositing eggs, and have no effect whatever upon borers that may already have entered the tree.

THE CODLING MOTH.

(Carpocapsa pomonella.)

This is one of the insect enemies that have supposedly come to us from the Old World, and it has now spread to nearly all parts of the United States where apples are grown. The annual damage to the apple crop of the country by this insect is enormous, being estimated by Prof. C. B. Simpson at 12,000,000 barrels, worth about $11,400,000.* The great majority of the "worms" found in apples are the larvae of this insect. An examination of a number of exhibits of otherwise fine apples from North Georgia was made by the writer during the past summer. It was found that fully 95 per cent. of these were wormy. Coming, as these apples did, from various sections of North Georgia, it is evident that the codling moth is at present working more injury to the apple crop of Georgia than any other pest, the San Jose scale not excepted.

The adult codling moth is a small but beautiful insect, but on account of its diminutive size is seldom noticed by the average apple grower. The adult moths are well illustrated in Figures 1 and 2.

The moths appear in the spring at about the time the apple trees are in bloom and eggs are deposited on both the young apples and on the foliage. There are many opinions as to how and where the young larvae first enter the apple but it is well established that a great majority of the spring generation crawl into the blossom end of the small apples and there burrow into the flesh of the latter. The larva, when partially grown, is of a delicate pink

*Bulletin 41, Division of Entomology, page 18.

Fig. 6—Showing the right time to spray for codling moth. The bunch on the left is at proper stage for spraying, while the apples on the right are too far developed for spraying to insure best results. (After a photo by A. L. Quaintance).

Fig. 7—A wormy apple showing the mass of brown material thrown out at the blossom end by the codling moth larvae. (After Slingerland, Bul. 142, Cornell University Exp. Station.)

color, and when matured may attain a length of one-half inch or over (See Figure 3).

Many of the wormy apples drop before attaining their full size, but the larvae within them continue to feed until grown, when they burrow out of the apple and select a protected place in which to spin their cocoons. Loose bark and rubbish offer favorable inducements to these larvae, and it is in such material in the apple orchard that many cocoons will be found. A knowledge of this habit is of importance as bearing upon the control of this insect.

REMEDIES.

Spraying with an arsenical poison has been found highly profitable, but this spraying must be done at the proper time or it will be of little value. **The right time for spraying is just after the petals have fallen, and while the calyx end of the apple is still open.** At this time it also will be noticed that the apples all stand erect in such a way that a drop of water or spray mixture will be held by the apple as in a cup. (See Figure 6). Thus the meal that awaits the codling moth larva is a poisoned one, and as most of the larvae enter the blossom end of the apple, they will not live to reach the interior of the fruit. This poison spray is best applied in the form of Bordeaux mixture 4-6-50 * to which either six ounces of Paris green or two and a half pounds of arsenate of lead is added. The poison shoud be mixed with a very small amount

*Bordeaux mixture is the most commonly used of all preparations for the control of mildews and fungus diseases of various kinds, although in itself it has little value as an insecticide except as a repellent. For convenience, the ingredients (copper sulphate, lime and water) of Bordeaux mixture, and their amounts, are designated by an abbreviated formula, the number of pounds of copper sulphate (bluestone) being written first, number of pounds of lime written second and number of gallons of water written last. Thus the formula "4-6-50" indicates a Bordeaux mixture made of 4 pounds copper sulphate, and 6 pounds lime in 50 gallons of water. The formula "3-9-50" would indicate 3 pounds copper sulphate, 9 pounds lime and 50 gallons of water, etc. Bordeaux mixture to be thoroughly effective must be prepared carefully. The following method of preparation will insure good results: Dissolve the bluestone in a barrel or tub, using a small amount of water. If hot water is used the bluestone will dissolve most readily. Before immersing in the hot water tie up the bluestone loosely in a piece of burlap suspended from a cord. Place this in the water and keep moving. The bluestone will have all dissolved in a few minutes, when this solution should be diluted with clear water to 25 gallons. In another vessel slack the required amount of lime, using boiling hot water and adding water from time to time to prevent burning. When slacked dilute to 25 gallons. Dip up these solutions with buckets and pour them together into a third barrel, holding the buckets so that they are emptied simultaneously and not too fast The streams should meet and mingle together in mid-air so that the solutions are thoroughly mixed before they reach the surface of the liquid in the barrel. When both solutions have been poured into the third barrel in this manner, stir up the mixture vigorously with a paddle and the Bordeaux mixture is ready for use. It is also now ready for the addition of Paris green or other poison, if poison is to be used. While spraying out the Bordeaux mixture only a pump with a good agitator should be used.

of water, into a paste, before it is added to the Bordeaux mixture. The arsenate of lead is preferable to Paris green, as the former is not so readily washed off by rains. Paris green, if used slightly in excess, is likely to burn the foliage severely, but with arsenate of lead, there is not this danger. This spraying should be repeated two weeks later, using the same formula for Bordeaux mixture and the same amount of poison. No danger may be apprehended from these early sprayings with poisoned Bordeaux, as by the time the apples are edible — even for cooking purposes — all of the poison will have been washed off by the rains. When it is also desired to control the apple scab, or where the apples are ordinarily attacked by the bitter rot fungus, a third spraying should be given the trees about three weeks after the second. It may be well to emphasize the point that by spraying, we do not mean "sprinkling." Spraying means a thorough but thin application of the spray mixture to all parts of the tree and foliage, as well as fruit, and this application can be made only with a good force-pump which is equipped with a good, fine Vermorel, Mistry or Bordeaux nozzle. He who "sprinkles" may expect failure.

Mention was made above of the fact that apples falling prematurely, contain the larvae in various stages of development. For this reason all wind-falls should be kept cleaned up during the entire season and either burned or fed to stock, in order that the larvae within them may be destroyed before having a chance to escape. In this way the future generations of the insect will be considerably reduced. Where apples are stored in cellars, bins or out-houses, the latter should be carefully and thoroughly screened to prevent the escape of adult moths which may develop from any infested apples placed in storage. Serious infestations by the codling moth have often been traced directly to carelessnesss in not properly screening storage cellars.

By taking advantage of the habit of the larvae, after leaving infested apples upon the tree, of crawling down the trunk to find a sheltered place in which to spin cocoons, we also have a simple method of trapping them by putting bands about the tree. For this purpose strips of burlap, old sacks or brown paper may be used. These bands should be four or five inches wide and held in

place by stout twine.* One band should be placed about the trunk of the tree and one around each principal limb. These bands should be put in place within three weeks after the blooming period and examined every week or ten days and all larvae, pupae or cocoons found under them destroyed. Although the cocoons are not over one-half inch in length, they are white in color and readily found. The bands must be examined at least every ten days to prevent the adults from escaping. **To place bands upon the trees and neglect them, furnishes the codling moth larvae with the most favorable conditions for successfully reaching maturity.**

*The orchardist should not be deluded by the glaring and enthusiastic claims made by the venders of patent "tree bands" and "worm traps." The best of them will serve the purpose no better than last year's worn-out cotton sacks.

DIRECTIONS FOR SENDING INSECTS AND PLANTS.

This office is at all times glad to render any assistance possible in determining the identity of insects and plant diseases and advising measures for their control.

Do not send insects in envelopes or pasteboard boxes by mail; they are inevitably crushed beyond recognition. Send living insects in strong wooden or tin boxes by mail. No openings are necessary to admit air. Whenever possible enclose some of the food-plant for the insects to subsist on while enroute; specimens showing the injury done are desirable. *The name and address of sender should be on every package.* It is against the postal regulations to enclose a letter in a box by mail unless sent at letter postage rate. Specimens of caterpillars, worms, etc., in alcohol or other liquid can be sent by mail *only when in regular mailing tubes.* We will be greatly aided if correspondents writing about insect pests will give as full a description of the habits, food-plants, injury and abundance as possible.

Specimens of twigs, living plants with foliage, etc., should be wrapped in damp (not wet) cotton cloth so as to reach us in fresh condition. Fruits showing injury or disease should be wrapped well with paper and packed in a wooden or tin box.

Correspondents can materially aid the work of this office by communicating with us concerning their success or failure in using the methods advised for controlling injurious insects and diseases, giving a careful detailed account of the methods used and the results obtained. Such information will prove of value to all.

WILMON NEWELL, State Entomologist.
R. I. SMITH, Asst. State Entomologist.

GEORGIA STATE BOARD OF ENTOMOLOGY

BULLETIN NO. 14—November, 1904.

Experiments With The San Jose Scale During 1904.

BY

WILMON NEWELL AND R. I. SMITH.

CAPITOL BUILDING . . . . : : : Atlanta, Ga.

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EXPERIMENTS WITH SAN JOSE SCALE DURING 1904.

In October, 1903, Bulletin No. 8 of the State Board of Entomology was issued, and contained directions for the preparation and application of the lime-sulphur-salt wash to orchard trees infested with San Jose scale. These recommendations have been closely followed by the great majority of the owners of infested orchards in Georgia, with uniformly good results. While a better scale remedy than the lime-sulphur-salt wash recommended in Bulletin No. 8 is not likely to be found in the near future, still it was deemed desirable to experiment further with a view to learning whether or not this preparation could be further simplified and its cost of preparation reduced.

Experiments conducted in other states have thus far failed to develop any more efficient preparation for treating scale-infested orchards, either in the North or in the South, although the formulas recommended by different writers vary greatly, as do also the methods of preparation advocated.

The writers have conducted experiments during 1904, both in spraying during the winter, and in spraying during the summer while the trees were in foliage and in growing condition. The former experiments have not

resulted in any new remedies or startling discoveries, but as their result we feel justified in recommending to the fruit growers, several lime-sulphur preparations, all of which are more cheaply and quickly prepared than the regular lime-sulphur-salt wash formerly advocated. For use in small or family orchards, we believe that we have found the correct method of satisfactorily preparing the lime-sulphur-soda wash, with which many parties have experimented with indifferent success. While this latter preparation is too expensive to be used upon a large scale in commercial orchards, it is well adapted to the small orchardist on account of the ease with which it may be prepared.

Our thanks are due to Mr. C. W. Withoft, Manager of the Ohio Fruit Land Co., for the privilege of using infested trees upon the plantation of the latter Company at Myrtle, Ga., as well as for very material assistance rendered in the way of laborers, materials, etc.

Experiments with Winter Washes.

The preparations used in the winter experiments were for the most part modifications of the lime-sulphur-salt wash, different amounts of these three materials being used. The wash was also prepared in different strengths, combined with copper sulphate, tar or caustic soda, as well as without the addition of any third substance. A few proprietary preparations and materials popularly recommended as scale-remedies were also tested in order to secure positive data regarding their efficiency.

In these experiments the standard formula for lime-sulphur-salt was taken as the standard for comparison. This formula, the same as recommended in Bulletin No. 8, is as follows:

Stone Lime	30 lbs.
Sulphur	20 lbs.
Salt	15 lbs.
Water	60 gallons.

The recommendations given in Bulletin No. 8, for preparing this wash were as follows:

"Place about one-fourth of the water in an iron kettle and bring to a boil. When the boiling point is reached add the unslaked lime, and

FIG. 1. SAN JOSE SCALE, *Aspidiotus perniciosus*. The twig upon the left is but slighty infested. The one on the right is badly infested but is not yet "incrusted."

during the consequent violent boiling add the sulphur (which should previously have been mixed with water) and keep well stirred. A few minutes later add the salt and continue the boiling for two hours. Water may have to be added from time to time to make up for evaporation —sufficient water should be kept in the kettle to prevent "burning," but more than this is not desirable. At the end of the two hours add water to make 60 gallons and strain through a fine mesh iron strainer into the tank of spray pump. Apply while still hot."

In all, 17 different mixtures were tested. The experimental work was commenced upon Feb. 26th, 1904 and plats 1 to 9 inclusive were treated upon the 26th and 27th. The treatment of the remaining plats was unavoidably delayed until March 2nd and 3rd. Upon the latter dates nearly 25% of the buds had commenced to show color and a few green leaf tips were beginning to appear. March 2nd is a much later date than we recommend for spraying with any of these preparations, but conditions were such that our experimental work could not be commenced as early in the season as desired. Owing to the advanced development of the buds we anticipated considerable injury as a result of the late applications, but this injury was much lighter than expected. In the notes upon the various plats, given below, special mention is made wherever unexpected or severe injury to buds or foliage resulted. Where no mention is made of the effect on buds it may be taken for granted that no injury worthy of note occurred.

In the preparation of the lime and sulphur mixtures, nearly all were prepared by first mixing the sulphur into a paste and adding it to the water, which had previously been brought to the boiling point. The stone lime was then added. In this way all heat generated by the slaking of the lime was utilized in dissolving the sulphur, and the time of necessary boiling was accordingly reduced. Previous experience, as well as these experiments, has convinced us that this method is much preferable to that of adding the sulphur to the lime after the latter has commenced slaking, as has been generally recommended. When salt, bluestone or other material was added, this addition was made after the lime had completely slaked. The lime-sulphur mixtures were first boiled in from one-fifth to one-fourth the entire amount of water. When the boiling was completed, water was added to dilute the wash to the required strength. The time of boiling, as

given below, refers to the time of VIOLENT boiling AFTER THE SLAKING OF THE LIME WAS COMPLETED. It was found that the amount of water in which the ingredients were boiled, could vary considerably without affecting in any way the appearance or efficiency of the final product.

Three careful examinations were made of the different plats. The first examination was made on March 12th, from ten days to two weeks after the sprayings. The second was made on April 27th, and the last examination upon June 28th, approximately four months after treatment. It was assumed that examinations made after this latter date would prove unreliable on account of the likelihood of the trees becoming re-infested from the adjoining unsprayed trees which were left as checks upon the experiment. In the plat-notes below reference to first, second and third examinations will refer to the dates given above.

PLAT 1. MIXTURE NO. 1.

Lime	20 lbs.
Sulphur	20 lbs.
Salt	10 lbs.
Water	60 gallons

Boiled 30 minutes.
Diluted with hot water.

When the first examination was made of this plat, about one-fourth of the scale was still alive. At the second examination about the same number were alive but no crawling larvae could be found upon these trees, whereas the trees in the check (unsprayed) plats were liberally covered with the crawling young. The third examination made prominent the prolonged action of this wash on the scale as at this time no young could be found upon the trees.

PLAT 2. MIXTURE NO. 2.

Same formula as Plat 1. Boiled 30 minutes. In the case of Plat 1 the mixture was applied directly after being prepared and while still hot. In the case of No. 2 the mixture was allowed to cool before being sprayed upon the trees. As was expected, considerable material crystalized out * and had to be discarded, so that the preparation applied to the trees was practically a clear liquid. The first examination showed at least one-half the insects still alive. Second examination showed an equal number of females still alive as well as a few young insects crawling about. Upon the third inspection only a few adults remained alive and no young could be found. This final result was

*A variety of opinions have been published as to the composition of these crystals. C. O. Houghton in a recent bulletin (No. 64) of the Delaware Exp. Station gives their composition as hydrosulphide of lime, $CA(SH)_2$

not without value but was by no means equal to that obtained in the case of Plat 1.

PLAT 3. MIXTURE NO. 3.

Lime ....16 lbs.
Sulphur ....20 lbs.
Salt ....10 lbs.
Water................................60 gallons
Boiled 1 hour
Diluted with hot water.

The object in testing this formula was to see whether it would yield as good results as when a larger amount of lime was used, as in the case of Plat 1. Suffice to say, that the results were not nearly so satisfactory, in spite of the fact that this lot was boiled one hour, as against a half hour's boiling in the case of No. 1.

PLAT 4. MIXTURE NO. 4.

Kerr's Compound................................1 part
Water ....20 parts
Mixed cold.

Kerr's Compound is a preparation, the composition of which is not made public by the manufacturers. The odor of the material would indicate that it contains considerable carbolic acid. This material mixes readily with cold water in any proportion, and when sprayed upon the trees covers the bark well, spreading much as does whale-oil soap solution. Various claims have been made for it as a remedy for San Jose scale. While we have tested it in former years without obtaining satisfactory results, there seemed a possibility that it might not have been properly prepared or mixed. In the present test, however, the Compound was brought to the orchard and mixed by the General Manager of the Kerr's Compound Co., Mr. S. H. Boynton, and the trees thoroughly sprayed with it under his personal direction.

Upon the first examination, two weeks after spraying, it was found that all trace and ordor of the mixture had disappeared, although the bark presented a greatly brightened appearance, as would naturally result from the application of any emulsion or soap solution. A considerable number of the old dead scales had also sluffed off. A casual glance would have given the impression that a considerable number of the scales had been killed, but a close examination showed the remaining scales upon the trees to be alive. Upon the second examination all adults were found alive and the trees were thickly covered with crawling young. The third inspection showed that the scales had multiplied sufficiently to seriously interfere with the growth of the trees and at this latter date the trees treated with Kerr's Compound showed no difference, so far as the scale was concerned, from the untreated trees. We are now forced to conclude that as a winter treatment for San Jose scale, this preparation has little if any value at all, and the fact that it is doubtless a good disinfectant may possibly make conditions even more favorable for the San Jose scale.

PLAT 5. MIXTURE NO. 5.

Lime ....16 lbs.
Sulphur................................20 lbs.
Salt ....10 lbs.
Water................................60 gallons
Boiled 1 hour

This mixture is the same, and was prepared in the same way, as the one used on Plat 3, but after being boiled and diluted to the required

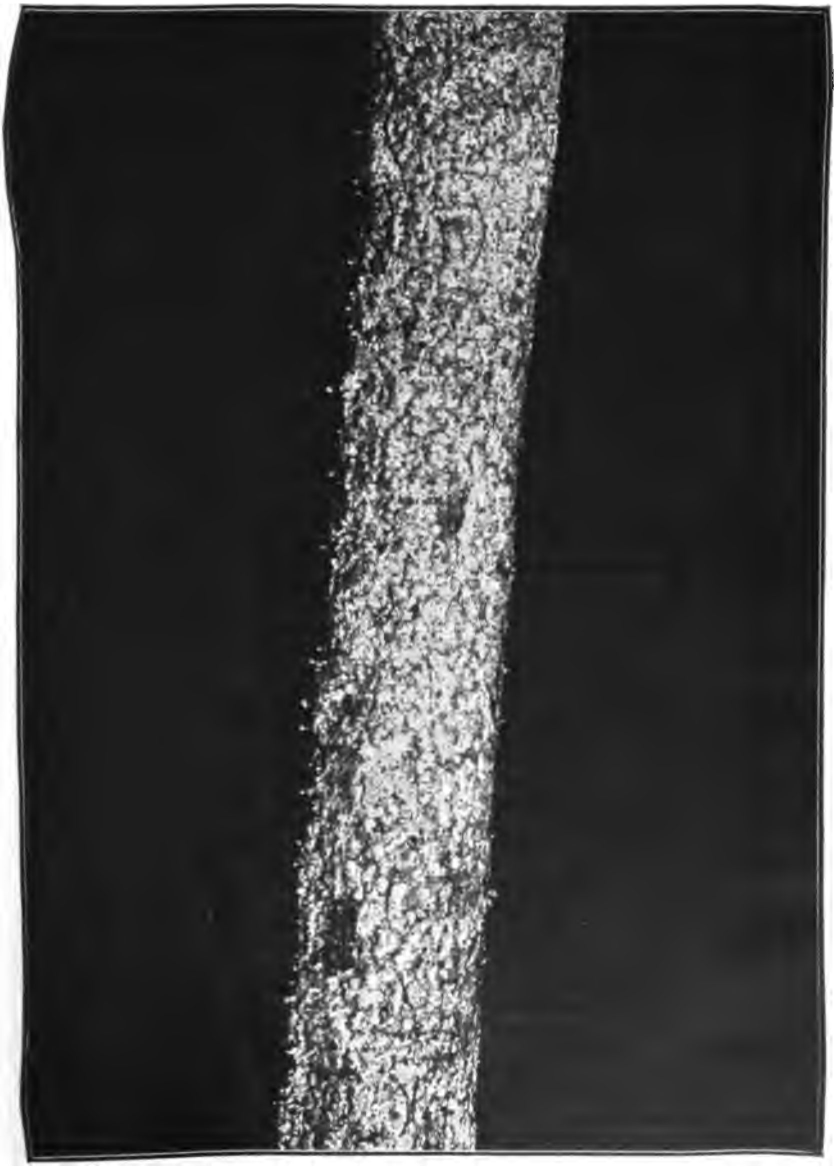

FIG. 2. WEST INDIAN PEACH SCALE. *Aulacaspis pentagona.* The winter treatment advised in this bulletin for San Jose Scale also effectually disposes of the West Indian Peach Scale.

degree, was allowed to cool and settle. The clear liquid was then decanted and sprayed upon the trees cold. Somewhat contrary to expectations this mixture gave fair results, being almost if not quite, equal in effectiveness to No. 3.

PLAT 6. MIXTURE NO. 6.

Same formula as No. 5.

In this case, the mixture after being boiled and diluted, was allowed to cool and settle for 45 minutes. During this time it did not become entirely cold. While still warm the clear liquid was decanted and sprayed. The difference between this mixture and No. 5 is not great, except that more of the materials would be in solution while the mixture was still warm, than when entirely cold. The results were so nearly the same as with No. 5 that no comparison could be made. It does not appear that there can be any advantage or saving by making the lime-sulphur-salt wash, and then discarding the solid portions, even if satisfactory results do follow the use of the liquid portion alone. The test was made to enable us to answer the question, frequently arising, as to the effect of the clear liquid when used alone.

PLAT 7. MIXTURE NO. 7.

Lime.. ....25 lbs.
Sulphur...... ....20 lbs.
Water..........................60 gallons
Boiled 35 minutes
Diluted with hot water.

This mixture was prepared in the usual manner, the lime being added to boiling hot water in which the sulphur had previously been mixed. When making the first examination of the sprayed trees, this plat was in some way overlooked, but a careful inspection was made at the date of second examination, April 27th, which showed the wash to be adhering well, and only a few live adult scales could be found. No larvae were found, showing that successful breeding had been prevented. The last examination June 28th, failed to reveal a single living scale insect.

The result with this mixture, containing only lime and sulphur, is particularly gratifying as it clearly demonstrates that the addition of salt to the lime-sulphur mixture is—so far at least as the San Jose scale is concerned—unnecessary.

PLAT 8. MIXTURE NO. 8

Lime...... ....20 lbs.
Sulphur........... ....15 lbs.
Water ....60 gallons
Boiled 20 minutes
Diluted with hot water.

This formula calls for a smaller amount of material than any other formula here given. The 20 minutes boiling in this case was sufficient to secure the characteristic yellowish-green color attained by all the lime-sulphur mixtures when they have been boiled sufficiently. First inspection of the trees sprayed with this mixture, revealed about 25 per cent. of the scales still alive. Upon the second examination it was found that fully as many adults were still alive and a few crawling young were also found upon the trees. The third examination showed that the action of the wash had been prolonged, as at this time only about 5 per cent. of the adult scales were alive, while no young could

be found. The results indicated that this mixture was somewhat below the necessary strength for satisfactory treatment of the scale.

PLAT 9. MIXTURE NO. 9.

Lime........................30 lbs.
Sulphur......................20 lbs.
Salt.........................15 lbs.
Water........................60 gallons
Boiled 1 hour
Diluted with hot water.

This is the same as the "standard" formula usually recommended and which was given in our Bulletin No. 8. last year. This mixture was tested with the others mainly for the purpose of comparison. The results were satisfactory and all that could be desired, but this wash does not present sufficient advantages over others which are simpler. For example, Mixture No. 7, containing the same amount of sulphur and less of lime, but no salt, and which was boiled for only 35 minutes, was fully as effective against the scale as this one. We have not taken into consideration the difference in the fungicidal value of the wash, which may possibly vary considerably with the presence or absence of salt. This point will be discussed upon a subsequent page.

PLAT 10. MIXTURE NO. 10.

Lime........................30 lbs.
Sulphur......................20 lbs.
Salt.........................15 lbs.
Water........................60 gallons
Boiled 35 minutes
DILUTED WITH COLD WATER.

This mixture is identical with No. 9 except that it received less boiling and was diluted with cold water instead of hot. The results obtained show it to be fully as efficient as where dilution was made with hot water.

PLAT 11. MIXTURE NO. 11.

Lime........................20 lbs.
Sulphur......................15 lbs.
Salt.........................5 lbs.
Water........................50 gallons
BOILED 30 MINUTES.
DILUTED WITH COLD WATER.

In this experiment we attempted to use the least amount of materials possible and still secure an efficient preparation; economy of time in preparation was also an object. In the preparation of the above, the desired color was not obtained by the 30 minutes boiling and some fears were entertained as to the final results. At the time of first examination only a small number of scales were found alive and the wash was adhering extraordinarily well. The second inspection found the preparation still adhering to the bark in considerable quantity and not a single living scale could be found. The third examination, June 28th, revealed two young scales upon the new growth of a single tree, and it seems quite probable that this was due to re-infestation from untreated trees near at hand. The results with this mixture were even better than was expected and the outcome further indicates that 5 pounds of salt to each 50 gallons of water is fully as effectual as a larger amount. It further emphasizes the fact that cold water can be used for diluting the

lime-sulphur mixtures, after boiling, with as good results as when hot water is used for this purpose.

PLAT 12. MIXTURE NO. 12.

Lime	15 lbs.
Sulphur	5 lbs
Commercial Caustic Soda	5 lbs.
Water	50 gallons

We experimented with a large number of different methods for preparing this mixture, combining the various ingredients in various ways, both with boiling and without. By following the usual recommendaion—made in other states—of slaking the lime and sulphur together and then adding the caustic soda, we obtained nothing better than a thick, brick-red compound, that was unsatisfactory from every standpoint. It is unnecessary to discuss the various processes tested, but the following method of combining these materials was found to be the most satisfactory.

The sulphur was first mixed into a paste, in an iron vessel, with a small amount of boiling hot water. The caustic soda was then slowly added and the mixture kept well stirred, boiling water being added from time to time to keep it from getting too thick. By this plan all of the sulphur was dissolved, giving a deep brown-colored liquid, perfectly clear. (The heat of the soda, together with that of the boiling water was found just about sufficient to perfect this solution, but at times it might be necessary to heat the mixture slightly to insure perfect solution.) To this clear brown liquid, the stone lime was added and the whole kept stirred while slaking. As soon as the lime was entirely slaked the mixture was diluted with cold water to the required amount and was applied to the trees. The entire time consumed in making this mixture, including time necessary for diluting, was but eight minutes. The final mixture secured had a yellowish-green color, in no way distinguishable from the regular lime-sulphur washes made by long continued boiling. It was thought that possibly the heat evolved by the slaking lime could be used to further aid in dissolving the sulphur but this was not found to be the case. Where lime was added to the mixture of sulphur and soda, before absolutely all of the sulphur was dissolved, the greater part of the sulphur almost immediately returned to its original form, and less of it remained in solution after the lime was added than before. The key to successful preparation lies in the COMPLETE SOLUTION OF THE SULPHUR WITH THE CAUSTIC SODA, BEFORE THE LIME IS ADDED.

This wash was applied to the trees upon March 3rd, and as many of the buds were open at this time, injury was expected. Later examinations showed that a few buds were injured, but the injury was much lighter than anticipated. At first examination the wash was adhering well; per cent. of live scale not estimated. The second examination revealed only a few adults alive and much of the mixture still adhered to the bark. At this time no young had appeared. At the time of third inspection a very few live adults and partially developed young scales were found.

In the preparation of this mixture, the writers had expected that the caustic soda would itself have some effect upon the scale, hence the relatively small amounts of lime and sulphur that were used. Later developments, however, showed that caustic soda by itself was practically worthless so far as being a scale remedy was concerned. (See notes on Plats 14 and 17 below.) Doubtless a mixture, similarly prepared, containing 7 to 10 lbs. of sulphur with equal amounts of caustic soda, would have given much better results.

Owing to the cost of making, this lime-sulpur-soda mixture does not commend itself to the commercial grower, but for the small orchardist or the party desiring to treat but a few trees upon the farm or on town premises, it is well adapted on account of the ease and rapidity with which it can be prepared, very little apparatus being necessary.

PLAT 13. MIXTURE NO. 13.

Lime.................... 20 lbs.
Sulphur.................... 15 "
Salt .... 5 "
Water....................50 gallons
Boiled 45 minutes.
Diluted with cold water.

This mixture differs from No. 11 only in that it was boiled 45 minutes instead of 30, until the desired yellowish-green color was obtained, The results were not noticeably different from those obtained on Plat 11, but upon this result alone we would not be justified in suggesting the use of lime-sulphur compounds with insufficient boiling.

PLAT 14. MIXTURE NO. 14.

Commercial Caustic Soda......1 lb.
Water ....6 gallons.

Early in the present year, a number of agricultural papers advocated the use of caustic soda as an efficient remedy for the San Jose scale. The first of these articles seems to have appeared in the January (1904) number of the Farm Journal and was supposedly written by a party in California. Great claims were made for it, and a number of agricultural papers copied the article in question, with the result that a number of fruit growers attempted its use. To determine its value in this connection, infested trees were sprayed by us with the above strength. Upon the first examination a considerable number of the scales seemed to be dead, but the second examination showed that while a large number of dead scales had sluffed off the bark, fully 60% of those remaining were alive and young lice were fairly abundant. The third examination failed to reveal any decrease in the number of adult insects and all were breeding freely. Compared with untreated trees upon the check plats, no difference in degree of infestation was observable.

PLAT 15. MIXTURE NO. 15.

Lime ....25 lbs.
Sulphur......................20 "
Copper Sulphate............. 4 "
Water........................60 gallons.
Boiled 35 minutes.
Diluted with hot water.

In this mixture copper sulphate was substituted for salt, as a good many inquiries have come to us regarding whether or not such a mixture would be effective against the San Jose scale. The mixture given above is essentially the same as the "Oregon wash" except that the amount of copper sulphate is considerably in excess of that used in the latter. In its preparation the lime was slaked in the usual way in the boiling mixture of sulphur and water. The copper sulphate (bluestone) was dissolved separately in hot water and added to the lime and sulphur

mixture, the whole being then boiled for 35 minutes. At the end of 35 minutes the mixture was diluted to make 60 gallons and sprayed while still warm. The trees shortly after spraying presented a very deep blue color, almost black.

The notes upon this plat show that the wash adhered remarkably well up to the date of the second examination and the effect upon the scale was very satisfactory. At the last inspection June 28th, only an occasional live scale could be found. Upon the whole, the effects of this preparation upon the scale were fully as good as where the regular lime-sulphur-salt wash was used. However, we fail to see where any advantage can result from the use of this mixture over other and simpler compounds. In the first place, the materials cost more than those for the lime-sulphur mixture or the lime-sulphur-salt. No increased effectiveness against the scale is secured. The fungicidal value of this mixture, containing the bluestone, is little if at all greater than that of the lime-sulphur-salt. Prof. W. M. Scott has long since demonstrated that the lime-sulphur-salt is fully as effective against the peach-leaf curl diseases as is strong Bordeaux mixture * and the latter contains considerably more bluestone than does the mixture given above. Prof. C. O. Houghton has also recently shown that by the addition of any considerable amount of copper sulphate to the lime-sulphur wash, the causticity of the latter, and hence its effect upon the scale, is much reduced. †

PLAT 16. MIXTURE NO. 16.

Lime	25 lbs.
Sulphur	20 "
Coal tar	1 gallon.
Water	60 gallons.

Boiled 30 minutes.
Diluted with cold water.

This mixture was tested mainly for determining whether the tar would increase the adhesiveness of the wash. As was expected, the wash remained upon the trees for a long time, but not long enough so that any superiorty for it in this regard could be claimed over other lime-sulphur mixtures. For some reason, injury to the buds by this combination was much greater than that caused by any other mixture tested. As the season was far advanced at the time application was made, but little importance can be attached to this excessive injury. The effect of this lime-sulphur-tar upon the scale was uniformly satisfactory but upon the whole this preparation does not present any advantages over the simple lime-sulphur.

PLAT 17. MIXTURE NO. 17.

Caustic Soda	1 lb.
Water	10 gallons.

No effect upon the scale observable at any time.

Leaving out of consideration caustic soda and Kerr's Compound, a marked uniformity of results was obtained with all the above mixtures. Plat No. 8, upon which was used a mixture containing but 15 pounds of sulphur

* Bulletin No. 6, Ga. State Board of Entomology, Jan. 1903.
† Bulletin 64, Delaware Experiment Station.

to each sixty gallons, is an apparent exception. The amount of sulphur in this wash is manifestly too small to secure satisfactory results. From the foregoing notes it will be noticed that all compounds containing lime and sulphur gave good results, but that compounds not containing these two materials gave uniformly unsatisfactory results. This seems to be accounted for by the prolonged, though slow, action which all of these compounds have upon the scale. These experiments seem to show quite conclusively that boiling these washes from 30 to 35 minutes (after lime has been slaked in the hot mixture of sulphur and water) gives as effective a compound as where the mixtures are boiled for an hour or more. That these washes may be safely diluted with cold water, after boiling, is also well demonstrated. From the list, a considerable number of combinations might be safely recommended for winter treatment of scale-infested orchards. The problem resolves itself therefore into the question of what remedies are most economical and what ones are best adapted to the conditions confronting each individual fruit grower. These points will be discussed more at length on a subsequent page under the head of "Winter Washes Specially Recommended."

Experiments With Summer Washes.

For years many attempts have been made to find or de vise a summer treatment for the San Jose scale, which would be effective and which would at the same time be harmless to the trees while in an active growing condition. The best of these preparations cannot be considered more than partially efficient, and the most that can be expected of them is to check the breeding of the scale for a short time. In Georgia, 15% kerosene emulsion has given perhaps as good results as any summer wash, but even with this preparation there is a great variation in the results obtained, even when the emulsion is properly made. Summer treatment with mechanical mixtures of oil have been advocated at times but such applications are dangerous in the extreme owing to the almost total impossibility of securing accurate proportions of oil and water. Kerosene emulsion is the safest

form in which to apply this material, but as stated above, the results have been so variable that during the past year, this Department has recommended kerosene emulsion only under exceptional circumstances. To test a number of preparations, regarding which we have received many inquiries, the experiments with summer washes were undertaken. It was our intention to use a 15% kerosene emulsion as the standard for comparison in these experiments, but as will be noted below, this emulsion gave about as unsatisfactory results as any of the other compounds.

The summer experiments were made July 28th and 29th, about two weeks after the peaches were picked, in a small peach orchard belonging to the Ohio Fruit Land Co., at Myrtle, Ga. The first examination of the treated plats was made on August 22nd, and although it had been our intention to make several examinations during the balance of the season, the poor results obtained made further examinations unnecessary. These experiments developed nothing but negative information—they simply show that failure may be expected from summer treatment with the materials and compounds listed below. Our only excuse for recording them here is to warn the fruit grower as to what he may expect if he undertakes their use. The majority of the trees treated in these experiments were Elbertas.

PLAT 18. KEROSENE EMULSION, 15%.

Whale Oil Soap	1½ lbs.
Kerosene	1½ gallons.
Water	8½ gallons

This emulsion was made in the usual way, by dissolving the soap in two gallons of hot water, adding this solution to the kerosene and pumping this mixture back into itself rapidly for ten minutes. Water was then added to make ten gallons. The emulsion was carefully prepared and the trees were thoroughly drenched with it, but the result was an entire failure. When examined August 22nd the trees were covered with fully as much live scale as were untreated trees near at hand. There was no injury to the foliage.

PLAT 19.

Whale Oil Soap (Good's Caustic Potash)	1 lb
Water	2 gallons.

It will be noted that this formula is considerably stronger than is usually recommended for summer treatment of the scale, a strength of

FIG. 8. PLUM PULVINARIA. *Pulvinaria amygdali*, upon plum leaves. This scale-insect passes the winter as partially grown individuals upon the bark of peach and plum trees in certain sections. The winter spraying measures herein advocated for San Jose Scale are effective against this pest also.

1 pound to each to 4 or 5 gallons being commonly suggested. No injury to foliage resulted. A few of the young crawling lice may have been killed by direct contact when the wash was applied, but when the trees were examined August 22nd both adults and young were fully as abundant here as on the untreated trees.

PLAT 20.

Tobacco Whale Oil Soap (Good's).....1 lb.
Water.................................2 gallons.

The result of spraying with this soap was identically the same as in the case of Plat 19. The foliage was apparently not injured—neither was the scale.

PLAT 21.

Kilscale.................... 1 gallon.
Water........... ....25 gallons.

"Kilscale" is a compound manufactured by the Thomson Chemical Co., of Baltimore, Maryland, and it has been suggested as a possible summer remedy for the San Jose scale. The manufacturers represent it to contain the essential ingredients of a regular lime-sulphur-salt wash, in a highly condensed form, and that when diluted per directions is equally as effective as the lime-sulphur-salt wash prepared in the usual way. The effects on the foliage, of spraying with Kilscale at above strength, were very pronounced. When the trees were examined, fully 60% of the leaves had fallen off and those remaining upon the trees were severely scorched and shot-holed. A close examination of the scale showed about 25% killed, but plenty of live scale remained and the young lice were quite abundant.

PLAT 22.

Kilscale.................... 1 gallon.
Water......................40 gallons.

At this strength, Kilscale caused only about 15% of the leaves to fall, but the remaining foliage was severely shot-holed. The effect upon the scale was practically *nil*, although a few young may possibly have been killed at the time of spraying.

PLAT 23.

Kilscale.................. .....1 gallon
Water..........................50 gallons

Reduced to 1-50, Kilscale did not seriously injure the foliage. All leaves were more or less shot-holed, giving the trees a ragged appearance. No apparent effect upon the scale.

PLAT 24.

Kerr's Compound................. 1 gallon
Water ....20 gallons

This same strength of Kerr's Compound was tested as a winter wash (See Plat 4, p. 8) with unsatisfactory results, but it was hoped that it would partially redeem its reputation as a summer treatment. The foliage was not injured but the numbers of the scale insects were not ap-

preciably diminished. When examined August 22nd all adults seemed alive and healthy and the trees were covered with crawling larvae. In another orchard, that of Mr. O. R. Flournoy at Fort Valley, the same strength of Kerr's Compound was tested upon badly infested plum trees. Examinations by the writers, of this orchard during the summer, did not indicate that the preparation had been any more effective here than in our experiments at Myrtle.

PLAT 25.

Kerr's Compound........... 1 gallon
Water.................... 40 gallons

No injury to foliage. No perceptible effect upon the scale.

PLAT 26.

Pixoline .... 1 gallon
Water..................... 20 gallons

Pixoline is a pine tar product manufactured by the Frederic Disinfectant Co., of Atlanta, and was thought by the manufacturers to be worthy of trial as a summer spray for San Jose scale. At this strength, Pixoline did not injure the trees or foliage. Nor was any effect upon the scale perceptible.

PLAT 27.

Pixoline.....................1 gallon
Water....................... 40 gallons

Harmless to both trees and scale-insects.

PLAT 28.

Zenoleum.....................1 gallon
Water........................20 gallons

Zenoleum is a liquid disinfectant manufactured by the Zenner Disinfectant Co. While so far as we are aware, they do not recommend Zenoleum as a scale remedy, still they were desirous of having it tested as such and it was accordingly included in our experiments. At above strength it proved harmless to the foliage, but had no apparent effect upon the scale.

PLAT 29.

Kerr's Compound.............. 1 gallon
Water.........................10 gallons

As Kerr's Compound, diluted 1 to 20, gave such unsatisfactory results as a winter wash, and as little more could be expected of it as a summer treatment at the same strength, it was decided to test it at 1 to 10. Even at this strength it did not injure the foliage, but its effect upon the San Jose scale was no more in evidence than when it was used at a weaker strength.

Of all the mixtures tested, none gave even promising results. Kilscale, the only material tested that apparently had any material effect upon the scale, injures the foliage to such an extent that as a summer treatment

it cannot be endorsed. The failure of the kerosene emulsion to be more effective may be due in part to the use of a poor quality of kerosene, as that used was purchased from a rural grocery store. Upon the whole, we are obliged to discourage summer treatment and urge the fruit grower to spray his trees thoroughly during winter, thus making unnecessary any summer treatment. In the case of infestations which are discovered in mid-summer and in which the trees are so thoroughly infested as to make it improbable that they will survive until winter, we suggest a thorough white-washing of the trunks and lower limbs with the lime-sulphur-salt wash, as first advocated by Prof. W. M. Scott. This will effectually clean off these portions of the tree and give the tree a much better opportunity to withstand the scale attacks until winter, when thorough treatment can be given. In thus white-washing the trunks and bases of limbs, the wash must not be allowed to get on the fruit or foliage. We are not inclined to endorse any other summer treatment, and this white-washing treatment is suggested only for the special cases mentioned. The fruit grower who knows that his orchard is infested with San Jose scale, and who neglects to give it the proper winter treatment, will only be disappointed if he expects the entomologists to come to his rescue in the following July or August, when his trees are rapidly succumbing to the attacks of the scale.

Winter Washes Specially Recommended.

As a result of the experiments given upon previous pages, together with extended experience in commercial orchards in various parts of the state, we feel justified in giving special prominence to the three mixtures given below, as suitable winter treatments for scale-infested orchards.

THE LIME-SULPHUR WASH.

Lime	21 lbs.
Sulphur	18 lbs.
Water	50 gallons.

Mix the sulphur into a paste with a small amount of water and then add to about 15 gallons of boiling hot wa-

ter in an iron kettle (or in the boiling tank, if steam is used) and stir thoroughly. Have this mixture at the boiling point and add the stone lime. While the lime is slaking, keep the entire mass thoroughly stirred so that as much as possible of the heat caused by the slaking lime may be utilized in dissolving the sulphur. Boil violently for not less than 35 minutes. This boiling should be continued until the mixture is of a dirty yellowish-green color. This wash, when sufficiently boiled, gives the trees a bright green color immediately after spraying. When dry, the sprayed trees become as white as they would be if painted with white lead. Water may have to be added from time to time during the boiling process to prevent the mass from becoming too thick. When the desired color is secured, dilute with either cold or hot water to make 50 gallons. The mixture is now ready for spraying upon the trees and it will be found to spray most readily if used before it cools to any considerable extent. While spraying, the mixture should be kept well agitated. Upon cooling, crystals will separate out, not only making the solution less effective but also tending to clog the pumps. In case a portion of the mixture remains over night and the crystals form in it, they can be again dissolved by re-heating. This re-heated material can be sprayed without difficulty. While we do not commend the reheating of this wash except when necessary it will probably be advisable to re-heat rather than throw away any of the material.

This wash is made with as small amount of material as we believe it possible to use and still secure uniformly good results. This wash will be found equally effective against scale in all parts of the state, but for the peach orchards of North Georgia we suggest the lime-sulphur-salt mixture given below. The lime-sulphur wash is pre-eminently adapted to the use of the fruit growers in Middle and South Georgia.

THE LIME-SULPHUR SALT WASH.

Lime	21 lbs.
Sulphur	18 lbs.
Salt	5 lbs.
Water	50 gallons.

This wash is prepared in the same way as the lime-

sulphur wash, and the salt added to the boiling mixture as soon as the slaking of the lime is complete. Where a good head of steam is available for boiling, the desired color is often attained by 20 minutes of violent boiling. The fruit grower will with a little experience be able to tell when the wash has been sufficiently boiled. The color of the mixture should be depended upon, rather than the time of boiling. Where there is any question about this point, the boiling should be continued for an hour or more. There is no possibility of boiling the wash too much and it is best to err upon the safe side.

There is some question as to whether the lime-sulphur wash alone has as great a fungicidal value as when the salt is added to it. We do know that an early February application of the lime-sulphur-salt will prevent the peach leaf curl, but we do not have any positive data on this point for the lime-sulphur alone. For the present at least, we suggest the use of the lime-sulphur-salt for the North Georgia orchards, in order that the leaf curl may be controlled with certainty, by the same application that controls the San Jose scale.

The Lime-Sulphur-Soda Wash.

Lime	16 lbs.
Sulphur	8 lbs.
Commercial Caustic Soda . .	8 lbs.
Water	50 gallons.

Mix the sulphur into a thick paste with a small amount of BOILING HOT water. Then add the caustic soda slowly (do not dissolve the soda in water) keeping the mixture thoroughly stirred. A brick-red color will appear almost at once. Continue the addition of the soda, and continue stirring, adding small amounts of hot water as may be necessary to prevent the mixture getting too thick. The soda should dissolve all of the sulphur in a few minutes, producing a clear deep red liquid. Unless the liquid is entirely clear, with no particles of undissolved sulphur remaining, the mixture must be heated until all sulphur is dissolved. IT IS ABSOLUTELY IMPERATIVE THAT ALL SULPHUR BE DISSOLVED AND A CLEAR LIQUID OBTAINED, BEFORE THE LIME IS ADDED. To the

clear liquid described, add the stone lime, previously weighed out, and while it is slaking keep well stirred. The completed preparation will have the familiar yellowish-green color characteristic of the lime-sulphur preparations. Dilute with cold water to the desired point and spray at once.

This wash is too expensive for general use in large or commercial orchards, but is well adapted to those cases where but a few trees are to be treated, as is often the case upon city or town premises. The effect upon the scale by this wash, is not as good as the regular lime-sulphur wash, and in the case of badly infested trees therefore, two sprayings should always be given, the first in December and the second in February before the buds open.

When and How to Spray.

Regardless of which of the above mixtures may be used, badly infested orchards should receive two thorough sprayings during the winter. The first spraying should be during December, while the second should be in February. The latter spraying MUST BE COMPLETED BEFORE THE BUDS COMMENCE TO OPEN. Theoretically, the later this spraying is done, the more pronounced will be its effect upon the scale, for the longer will the wash remain upon the trees after the scale begins breeding. However, the fruit grower must time his spraying operations well in order to finish this February spraying before the buds have advanced to the point where they will be injured by the wash. The latest date at which this spraying can be done with safety varies greatly with the seasons and varies in different parts of the state. In Middle Georgia it is best to figure upon having this spraying completed by February 20th, while north of Atlanta it is not infrequently the case that this spraying can be continued safely until as late as March 4th. The individual fruit grower must judge as to the development of the fruit buds and be governed accordingly. In orchards but slightly infested the February spraying alone, if thoroughly done, will be sufficient to hold the scale in control until the following winter.

In spraying an infested orchard, EVERY tree should be

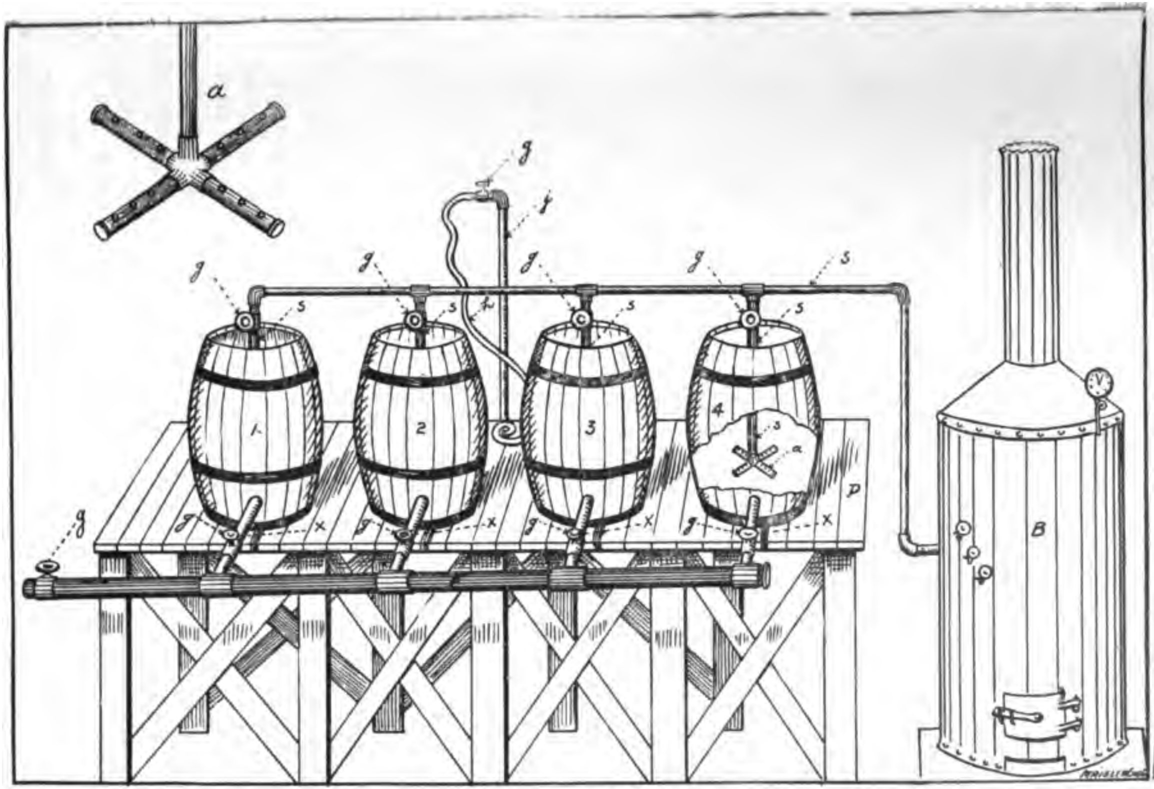

FIG. 4. A Simple Steam Boiling Outfit for Preparing Lime-Sulphur Washes: *B*, boiler; *ss*, steam pipes; *gg*, globe valves; 1, 2, 3 and 4, 50-gallon barrels; *xx*, pipes for drawing off mixture after boiling; F, large pipe carrying liquid from pipes *xx* to wagon tank or spray-barrel; *a*, lower end of steam-pipe with cross-arms and one-eighth inch openings for escape of steam; P, platform 6 feet above ground; *j*, pipe supplyn water from elevated tank or steam-jet; *h*, water hose for carrying clear water to 1, 2, 3 and 4.

sprayed. It has been demonstrated time and again that TO SPRAY ONLY THOSE TREES SHOWING INFESTATION IS FALSE ECONOMY. A tree that bears but a few individual scales this winter, may become entirely incrusted with scale, and its vigor seriously impaired by next winter, if allowed to remain unsprayed. The spraying should be thorough over the entire orchard whether scale is to be found in all parts or not. It is interesting to note in this connection, that many of our leading peach growers, among them Mr. J. H. Hale, assert that the beneficial effects upon the trees of spraying with the lime-sulphur wash are more than sufficient to pay for the cost of preparation and application, even where San Jose scale is not present.

Each tree should be sprayed thoroughly. By a "thorough" spraying we mean that every particle of bark above ground must be coated. When the trees have dried, after the first spraying, the points and twigs that have been missed are easily detected, and where there is any marked infestation of the orchard, the latter should be gone over carefully a second time and all these bare spots "touched up."

Equipment for Boiling and Spraying.

For small orchards the lime-sulphur washes can be prepared in iron kettles, arranged over a brick arch. For convenience, where there are many trees to be sprayed, these kettles should be of not less than 60 gallons capacity. While it is possible with two such kettles, or even one, to prepare the wash for a good-sized orchard, still the use of steam for boiling is so much more rapid and economical that the average orchardist will find it profitable in the end to equip himself with a steam boiling plant. The size and capacity of this plant will depend mainly upon the size of the orchard. A boiling outfit of this kind is shown in figure 4, to give an illustration of the general plan followed in arranging tanks, pipes, etc. The individual will readily modify this plan to suit his own conditions and facilities.

In the first place it is important that this plant be located in or near the orchard, or at some central point which is readily accessible to the orchards to be sprayed. It is

equally important that the outfit be located at a suitable water supply. If water from an elevated tank or from town waterworks can be utilized, so much the better. Failing this, the plant should be located at a spring, well, or stream of clear water, in order that the water may be delivered to the boiling tanks by a steam jet, thus saving the time and labor necessary to handle it with buckets. An equally important point is to have the elevated platform, upon which the boiling tanks are located, at least six feet above the ground, so that the mixture after being boiled can be drawn off directly into the spraying tanks or barrels. Almost any boiler of sufficient steaming capacity can be utilized for furnishing the steam. Boilers located at cotton gins, saw-mills, etc., are often made use of by placing this boiling outfit near them and making the necessary connections. Portable boilers, such as are used for sawing wood, or as traction engines, can be utilized to good advantage. For a small boiling outfit a good steam feed-cooker will answer the purpose very well. For boiling the mixture, either barrels or tanks can be used. If tanks are decided upon, these should not exceed 150 gallons capacity under any circumstances. The larger the boiling receptacle the more stirring will be necessary. Upon the whole it is usually better to use a large number of 100 gallon tanks or of 50 gallon barrels than to use fewer and larger tanks. Added convenience in preparing small amounts of the wash is also secured where barrels are utilized. A separate globe valve should control the steam supply to each barrel or tank. Particular attention is called to the cross-arms "A" in the Figure. These cross-arms deliver the steam at several points near the bottom of the barrel and this assists very materially in keeping the mixture stirred up. The cross-arms have one-eighth inch holes bored in them for the escape of steam. Each barrel should also have its outlet pipe controlled with a globe valve. It is convenient to have all the outlets open into a common discharge pipe as shown in the Figure. In this way the material can be drawn off from any one, or from all of the tanks at one time.

While the Figure represents only a single water-supply pipe with hose attached, for delivering water to the vari-

FIG. 5. A Suitable Spraying Outfit for a Medium-Sized Orchard. (Eclipse pump mounted in barrel, two leads of 20-foot hose, 6-ft. iron extension rods and single Vermorel nozzles).

ous barrels, it is a simple matter to furnish a water supply pipe for each barrel or tank. Mr. J. H. Hale, at his Fort Valley (Ga.) orchard has adopted the novel plan of connecting his water supply pipe with the common outlet pipe (corresponding to "F" in Fig. 4.) and by this arrangement can fill any one or all his barrels without extra piping. While but four barrels are represented in our Figure, still the individual grower will enlarge his plant to the capacity needed and will also add such other conveniences as may seem desirable. A set of scales upon the same platform with the boiling tanks is convenient, as are also steps for getting on or off the platform. The entire outfit, including boiler, can be covered with a shed and a store-room for lime, sulphur, etc., can be added upon a level with the platform, thus facilitating the handling of the materials.

The spraying outfit to be used will depend largely upon the size of the orchard to be sprayed. In the case of very large commercial orchards, wagon tanks, holding from 200 to 250 gallons, should be used. These tanks can be purchased from any of the manufacturers of good spraying apparatus at prices ranging from $10 to $20, and these tanks can be used upon any ordinary farm wagon. For winter work wagons with broad tires are preferable. The necessary pump, hose, extension pipes and nozzles to go with such a wagon tank will cost from $12.00 to $20.00, depending upon make, etc.

For small orchards of 10,000 trees or less, barrel pumps answer well. Good pumps of this style, mounted in sound barrels of 50 gallons capacity, complete with hose, agitator, extension pipes, and nozzles can be purchased at from $14.00 to $20.00 each. Such an outfit is shown in Figure 5. * It is only necessary to place such a pump in a light wagon and it is ready for use. For winter spraying in Georgia peach orchards every pump should be equipped with two leads of hose, each not less than twenty feet in length. Where the trees are planted far apart, 30-foot lengths of hose are even better, enabling the men to get around the trees readily

* The outfit shown was photographed during some experimental work in early summer, and the trees are shown in foliage. The pump was at the time being used for spraying Bordeaux mixture, but the same outfit is equally adapted to winter work with the lime-sulphur preparations.

and to good advantage. Each line of hose should have fitted to it a 6-foot extension rod, at the end of which is the Vermorel or Mistry nozzle. These extension rods are readily made by any blacksmith from quarter-inch gas-pipe. A stop-cock at the lower end of this extension rod (at its junction with the hose) is also a great convenience, in order that the operator may turn off the flow without having to reach or handle the nozzle. We have heard some complaints about the difficulty of spraying with the lime-sulphur washes on account of the hands and face becoming sore as a result of the caustic properties of the wash. If extension pipes, long leads of hose, and reasonable care are used, there will be but a minimum of difficulty from this source. Where extension pipes, or suitable substitutes therefor, are not used and the operator must work with his hands actually holding the nozzle itself, sore hands will result as a matter of course. The long leads of hose enable the operator to work at some distance from the wagon, so that the spray is not blown upon the team or upon the man working the pump. If the hose connections are kept tight there is no reason why the workmen should continually have their gloves and clothes saturated with the mixture. In spraying when there is a breeze, the team should always be driven against the wind or diagonally against it, so that the spray is blown from the team and wagon instead of towards them. Additional protection can be secured for the workmen by having them wear slickers or suits of oil-skin. Rubber gloves have often been suggested for protecting the hands but we have found it almost impossible to secure rubber gloves that would last any length of time. The cheapest leather gloves obtainable, thoroughly saturated before use with lubricating oil, will be found the cheapest and most serviceable. The faces of workmen can be protected by canvas masks if necessary and the caustic action of the wash may be lessened by liberal applications of vaseline or petrolatum to the skin. Precautions of this kind are almost an absolute necessity when colored laborers are employed, as they will usually persist in spraying against the wind anyhow, in spite of all advice that may be given them.

Suitable strainers must be provided for all pumps, and

the wash, as it comes from the boiling tanks, thoroughly strained before being placed in the spray tank. Copper strainers cannot be used for this purpose. The strainers must be of iron or brass.

For small or family orchards a bucket pump and a two-gallon pail will answer the purpose. Such a bucket pump should always be equipped with not less than ten feet of hose if anything larger than small shrubs are to be sprayed. With the short 3-foot piece of hose usually furnished by the manufacturers with these pumps, it is impossible to properly spray an average sized peach or plum tree. These bucket pumps can be bought at prices ranging from $6.00 to $9.00.

In handling the lime-sulphur mixtures, copper vessels and apparatus must be entirely avoided, as the wash has a marked corrosive action upon the copper. The ordinary copper knapsack pump cannot be used as it will be eaten up in a few days time. Iron vessels and apparatus should be used as far as possible. The wash acts slowly upon brass, but its action upon the better makes of barrel pumps will not be appreciable if these latter are thoroughly rinsed out with clear water each night. At the close of the spraying season of course the entire pump should be thoroughly cleaned, all parts well oiled, and the pump kept under suitable cover until again needed.

Dipping Trees in a Lime-Sulphur Wash Before Planting.

A considerable number of fruit growers have adopted the plan of dipping their peach and plum trees in solutions of lime and sulphur, made in the usual way, before planting, as an additional precaution against the San Jose scale. While we personally know of many thousand trees that have been dipped in this way before planting, without any injury resulting, we did encounter a single case during the past winter, in which marked injury followed. In this particular case 2,000 peach trees were dipped by an orchardist who is well known for his extreme carefulness. The trees were dormant, and at no time were they exposed to drying winds. To guard against the possibility of this orchardist having made the wash too strong through some mistake, we personally visited his orchard, made the wash ourselves, and

dipped more trees from the same lot. Injury followed, and the most careful investigation of all the conditions, together with a chemical examination of the lime and sulphur used (the lime and sulphur were not found to contain any foreign substance to which the injury could be attributed) has convinced us that the regular lime-sulphur-salt wash, properly prepared, did in this case injure the trees. As illustrating a case of safe use of this same wash under even more unfavorable conditions, we take the liberty of quoting as follows from a letter by Mr. J. H. Hale, dated June 28th, 1904:

"Replying to yours of the 21st in relation to dipping nursery trees in lime and sulphur wash before planting, I have to say that during the season of 1903 in Connecticut, we dipped about 3,000 peach trees and about 4,000 apple trees and saw no ill effects whatever from it. During April, 1904, we dipped about 6,000 apples and about 8,000 peach trees. Perhaps 500 of these had their roots dipped and the balance only the body of the tree. They were simply dipped in barrels of mixture containing 15 pounds of sulphur and 20 pounds of lime boiled together for about 40 minutes. No attempt was even made to shake off the material after they were dipped and not a particle of harm was done them in any way. With Prof. Henry of the Wisconsin Experiment Station, we also dipped whole branches of growing trees in this mixture at a time when the plum buds were showing considerable white and the peaches showing pink. I supposed of course that we had killed them, but these blossoms all set fruit and were O. K. when I left home a week ago."

In view of our own experience with injury from dipping trees, we cannot for the present recommend the practice. Dozens of fruit growers will attest to the safety of the proceeding, but we have a single case where the results were otherwise, and until we have determined under what circumstances or conditions such injury results from dipping, the fruit grower must do such dipping upon his own responsibility. We might suggest also in this connection, that where trees are properly fumigated before being planted out, there is but little advantage to be gained by dipping.

Spray Pumps and Materials. *

For the convenience of the fruit grower, we list below

*The list of manufacturers and dealers here given is solely for the convenience of fruit growers and is not in any sense an advertisement or endorsement of the parties mentioned. We do not show partiality to any firm or dealer. Other firms who wish to be mentioned in future lists of this kind can have their addresses included by communicating with us, and convincing us that they are handling only first-class machinery or materials at reasonable prices. Under no circumstances will firms be mentioned in our publications, whose dealings are known to be in any way questionable.

a number of manufacturers of spraying machinery, dealers in the same, etc.

MANUFACTURERS OF SPRAYING MACHINERY:

Goulds Manufacturing Co., Seneca Falls, N. Y.
The Deming Company, Salem, Ohio.
Morrill & Morley, Benton Harbor, Mich.
Field Force Pump Co., Elmira, N. Y.
Myers Pump Co., Ashland, Ohio.
Geo. H. Stahl, Quincy, Ill.
Spray-Motor Co., Buffalo, N. Y.

GEORGIA DEALERS IN SPRAYING MACHINERY:

Beck & Gregg Hardware Co., Atlanta, Ga.
P. J. Berckmans Co., Augusta, Ga.
Mallary Mill Supply Co., Macon, Ga.

GEORGIA DEALERS IN SPRAYING MATERIALS:

The following drug houses have in the past made a specialty of furnishing spraying materials, such as sulphur, copper sulphate, etc., used by fruit growers:

John B. Daniel, Atlanta, Ga.
Jacobs Pharmacy Co., Atlanta, Ga.
N. L. Willet, Augusta, Ga.

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State Board of Entomology.

FEBRUARY, 1905. BULLETIN No. 15.

An Inquiry Into the Cyanide Method of Fumigating Nursery Stock.

BY

WILMON NEWELL.

CAPITOL BUILDING. : : : Atlanta, Ga.

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STATE BOARD OF ENTOMOLOGY.

FEBRUARY, 1905. BULLETIN No. 15.

AN INQUIRY INTO THE CYANIDE METHOD OF FUMIGATING NURSERY STOCK.*

BY WILMON NEWELL.

The fumigation of dormant deciduous trees and shrubs with hydrocyanic acid gas is now generally conceded to be the most reliable and effective method of ridding these plants of such insects as woolly aphis and San Jose scale. The process is in general use throughout the United States, and in many states nurserymen are required by law to fumigate their nursery stock with hydrocyanic acid gas before placing it upon the market.

For several years past, Georgia nurserymen have been required to fumigate all deciduous nursery stock sold, and as this work has been largely under the direction of the writer he has had many opportunities to note the effectiveness of the method. In some cases it has been found that living San Jose scale has successfully passed through the fumigating process, even where the operators were trustworthy and careful, the fumigating houses apparently air-tight, and the chemicals used guaranteed to be pure. In view of the extremely poisonous

* For a general discussion of this process see Bulletin No. 11 of the Georgia State Board of Entomology, which will be sent on request.

nature of hydrocyanic acid gas, these failures of the fumigating process to be thoroughly effective seemed all the more remarkable. The great effectiveness of hydrocyanic acid gas will be understood when it is realized that when one ounce of 98% cyanide of potash (with necessary amounts of sulphuric acid and water) is used to 100 cubic feet of space, the amount of gas evolved constitutes only about three-tenths of one per cent. of the combined mixture of gas and air within the fumigatorium. Never-the-less, in an experiment carried out under the direction of Prof F. M. Webster, trees heavily infested with San Jose scale and protected with a heavy layer of earth failed to show any live scale-insects within a year after being fumigated with the above amount of cyanide.*

It therefore seemed desirable to institute an inquiry into the fumigating methods and chemicals used, with a view to determining the causes of these occasional failures. Chemical analyses of various potassium cyanides upon the market were first undertaken, and as the work progressed additional lines of investigation suggested themselves. A number of important points have been brought to light which we believe have been largely overlooked by inspectors and others who have been using the cyanides for fumigating nursery stock. While the investigations have by no means been completed, still the facts obtained seem to warrant their publication at this time.

Dr. Edgar Everhart, President of the Southern College of Pharmacy, was employed to make the chemical analyses, and the analyses given herein are entirely his work. The writer is also under many obligations to Dr. Everhart for many valuable suggestions relative to the lines of investigation which should be pursued, and in fact the present bulletin is little more than a resume' of Dr. Everhart's work.

It is regretted that circumstances are such that this investigation cannot at present be pursued further. There are many interesting points which remain to be determined. An examination of the various sulphuric acids upon the market, to determine to what extent they may

* We do not know of any published account of this experiment. The facts were communicated to the writer in a personal letter from Prof. Webster.

contain hydrochloric, nitric or other acids, would be valuable, as the work already done shows conclusively that the presence of any mineral salt (other than sulphates) in the cyanides, or free inorganic acid mixed with the sulphuric acid used, will result in the decomposition of a considerable amount of the prussic acid * evolved. An inquiry into the physiological changes which may take place in plant tissues as a result of exposure to prussic acid, and the extent to which the resistance of the plant may be modified or altered with relation to other insecticides or fungicides, applied subsequent to the fumigation, would doubtless open up a most interesting field and the results obtained would in all probability be of immediate practical application. For example, a case was encountered in which peach trees were dipped in a lime-sulphur mixture within a few days after being fumigated, with consequent severe injury. Careful investigation of all the conditions failed to reveal any cause for this injury and it seems possible that the effect of the hydrocyanic acid gas was to increase the susceptibility of the trees to injury by the lime-sulphur mixture.

History of Fumigation with Hydrocyanic Acid Gas.

The credit of first discovering the efficiency of hydrocyanic acid gas against scale-insects belongs to Prof. D. W. Coquillett who, while experimenting with the Black scale, Cottony-cushion scale and San Jose scale in California during 1886, found that this gas would readily kill these insects.† In 1889 he found that the best results were secured by adding the dry cyanide to a mixture of one part sulphuric acid and two parts of water. This plan and these proportions have, with slight variations, been in general use ever since. Prof. Coquillett's experiments in the fumigation of infested orchard trees continued in California for several years, and in the spring of 1894, soon after the discovery of San Jose scale at Charlottesville, Va., he carried on further experiments in fumigating scale-infested trees at that point.‡

* In this bulletin the term "prussic acid" is used throughout as synonymous with "hydrocyanic acid gas."

† Report of the Commissioner of Agriculture for 1887, page 124.

‡ Insect Life, Vol. VI, p. 324.

The first use of hydrocyanic acid gas for fumigating nursery stock seems to have been by Mr. W. R. Gunnis of the San Diego county (Cal.) board of horticultural commissioners, who in 1894 reported to Dr. L. O. Howard of the United States Department of Agriculture, that he had successfully fumigated 40,000 infested trees, generating the gas beneath large sheets with which the trees were covered.* While in the earlier experiments in fumigating orchard trees, the 58% cyanide of potash was generally used, it appears that Mr. Gunnis was among the first to adopt the 98% cyanide, for in January, 1896, he reported that he had used one ounce of the 98% cyanide to each 100 cubic feet of space to be filled by the gas.†

We have not been able to learn who first constructed boxes and houses for fumigating nursery stock, although tight buildings lined with felt were recommended by Prof. F. M. Webster in 1897,‡ and during the same year Prof. Webster fumigated considerable stock at Dayton, Ohio, using a small building therefor. We believe this to have been the first fumigating house used—at least in the East.

Since 1898 the use of one ounce of 98% potassium cyanide to each 100 cubic feet of space to be fumigated has been general. The amounts of sulphuric acid and water used with the cyanide have varied to a considerable extent, the majority of recommendations, however, specifying an amount of acid in excess of what was theoretically necessary for chemical combination with the cyanide. The amount of water mixed with the acid has also varied. This discrepancy in the formulae advised by different entomologists was practically disposed of by the adoption of the "1-2-4" formula, i. e., one ounce of 98% cyanide of potash with two fluid ounces of acid and four of water, by the Association of Horticultural Inspectors in 1903.

Examination of Cyanides Sold by Various Dealers.

Upon the discovery that fumigation was not in all cases effective, even under conditions that apparently met

* Bul. No. 3, n. s., Div. of Entomology, p. 60.
† *loc. cit.*
‡ Bul. 81, Ohio Exp. Sta.

every requirement, it was immediately suspected that the cyanide of potash used was not as represented. Samples of cyanide were purchased from various sources, the dealers of course being ignorant of the purpose for which they were desired, and in many cases not even aware of the identity of the purchaser. The amount of prussic acid in each was determined by Dr. Everhart and the results are given in the table below. It should be understood at the outset that the amounts of prussic acid are expressed in their equivalents of potassium cyanide (KCN). In the event of a sample containing a large amount of sodium cyanide (NaCN), which contains more prussic acid weight for weight than potassium cyanide, the percentage of cyanogen may, when expressed in its KCN equivalent, exceed 100%.

It will be noticed from the table, that the earliest examinations did not take into account the possibility of sodium chloride (common salt) being used as an adulterant. The importance attaching to this point was not discovered until later in the investigations.

From these analyses we are forced to the conclusion that the greater number of cyanides sold to nurserymen for fumigating purposes are far from being 98% pure, and while we regret to say so, many wholesalers and manufacturers have filled orders for "98%" cyanide, with inferior stuff totally unfit for fumigating purposes and of course entirely unreliable. This has been done either intentionally or through gross carelessness. Neither is excusable.

Under such circumstances it is therefore an occasion of much satisfaction when a really good cyanide like that manufactured by Merck & Co., or that manufactured by the Baker & Adamson Chemical Co., is encountered. In our opinion a purer cyanide than that which we purchased of the Baker & Adamson Chemical Co., could not be manufactured. With reference to Merck's, the fact that two samples purchased approximately six months apart, one from a retail dealer and the other from the factory, varied but .03% in the amount of KCN contained, and that both samples were free from adulterants, speaks well for the reliability of their product and the care which must be exercised in its manufacture and packing.

TABLE I. ANALYSES OF VARIOUS SAMPLES OF POTASSIUM CYANIDE.

Sample No.	Date Purchased.	Purchased of	Manufacturer	% KCN Represented or Guaranteed	% KCN Actually found by Analysis	Amt. Sodium Chloride Present	See Footnote
1	June 27—04	Retail Druggist, Atlanta, Ga.	Unknown	98	45.5	Not Determined	b
2	June 27—04	John B. Daniel, Atlanta, Ga.	Merck & Co.	"98-100"	99.77	None	a
3	July 26—04	Jacobs Pharmacy Co., Atlanta, Ga.	Roessler & Hasslacher	99	98.85	Not Determined	
4	Nov. 12—04	Alabama Nursery Co., Huntsville, Ala.	McKesson & Robbins.	99	92.95	" "	b
5	Nov. 15—04	Retail Dealer No. 1, Marietta, Ga.	Unknown.	98	44.77	" "	b
6	Nov. 18—04	Alabama Nursery Co.	McKesson & Robbins	98	96.77	" "	
7	Nov. 30—04	(Received from a Georgia Nursery)	McKesson & Robbins.	———	93.72	" "	
8	Dec. 12—04	Retail Dealer No. 2, Marietta, Ga.	Mallinckrodt.	"Fused"	49.85	12.71%	b-f
9	Dec. 17—04	Alabama Nursery Co.	McKesson & Robbins.	"98-99" (Original sealed 1 lb. can)	108.4	12.35%	c
10	Dec. 22—04	Mallinckrodt Chemical Works, New York.	Mallinckrodt.	"C. P."	96.4	10.18%	d
11	Dec. 22—04	Merck & Company, New York.	Merck & Co.	"98-100"	99.74	None	
12	Dec 23—04	Baker & Adamson Chem. Co., Easton, Pa.	Baker & Adamson	99	99.91	None	
13	Dec. 26—04	Roessler & Hasslacher Chem. Co., New York	Roessler & Hasslacher	"98-99"	98.11	9.19%	e

a. Examination for sodium chloride in this sample was made several months after the first analysis.

b. In justice to the dealers whose cyanide was found impure and below the required standard of 98 per cent. it should be said that all of them, upon being advised of the impurity of their cyanide, promised to immediately discard the stock on hand and secure cyanide for their trade which was of the required purity. The retail dealer is not always at fault, for jobbers and manufacturers are often known to fill orders for 98 per cent. cyanide, with the commercial fused cyanide running from 40 to 60 per cent. In the case of sample No. 1, we examined the bill of sale sent the retail dealer in Atlanta, and this bill specified 98 per cent. cyanide Yet upon analysis this same cyanide was found to contain but 45.5 per cent. KCN.

c. Sample No. 9 is composed largely of sodium cyanide, rather than potassium cyanide, hence the apparent high percentage composition when expressed in terms of KCN. It was found that the presence of the sodium chloride caused a decomposition of a considerable amount of the prussic acid evolved, as will be shown in detail further on. The 12.35 per cent. of sodium chloride caused such a decomposition that the total amount of prussic acid evolved and AVAILABLE from this sample, approximated the amount that would be secured from a chlorine-free cyanide analyzing 95.10 per cent. KCN. When expressed in terms of efficiency for fumigating purposes this cyanide is therefore virtually a "95.10" per cent. cyanide.

d. Contained 6.15 per cent. chlorine, corresponding to 10.13 per cent. sodium chloride.

e. Contained 5.58 per cent. chlorine, corresponding to 9.19 per cent. sodium chloride.

f. Contained 7.5 per cent. chlorine corresponding to 12.71 per cent. sodium chloride.

What Takes Place in a Fumigatorium?

It was decided to obtain a knowledge of something more than the mere fact that hydrocyanic acid gas is liberated when potassium cyanide is added to a mixture of sulphuric acid and water.*

Experiments were therefore made to determine the exact amount of prussic acid evolved and *available* from a given amount of KCN of known purity, the amount of KCN that remained unaltered and the amount of prussic acid decomposed [and therefore lost] in the reaction.

"One ounce of 98% cyanide to each 100 cubic feet" has for several years been accepted as the standard amount of cyanide for the fumigation of hardy dormant deciduous trees, yet so far as we can learn, no one has attempted to arrive at the exact amount of free and available prussic acid which is secured in practice from this amount of cyanide. We have fallen into the somewhat ridiculous error of considering so much cyanide of potash as our standard, when in reality the amount of free available prussic acid should constitute the standard regardless of what the percentage composition of the potassium cyanide may be.

To determine the points above-mentioned, the following experiments were made.

Experiment 1—A porcelain evaporating dish was placed on the sill outside of one of the laboratory windows, and into it was poured four fluid ounces of water and to this was added two fluid ounces of sulphuric acid.† Immediately afterwards, one ounce of very pure cyanide (99.7% pure). wrapped in filter paper, was dropped into the mixture and the window quickly closed. Almost instantaneously reaction occurred, large volumes of gas escaping from the liquid and appearing as a whitish cloud.‡ After five minutes the violence of the reaction ceased and after ten minutes no escape of gas was perceptible. After

*The reaction is $KCN + H_2SO_4 = HCN + KHSO_4$ and not "$2KCN + H_2SO_4 = 2HCN + K_2SO_4$" as given in Johnson's "Fumigation Methods."

†Wherever reference is made in this paper to sulphuric acid, a specific gravity of 1.84 is implied.

‡Pure HCN is of course colorless and the whitish appearance of the escaping gas is proably caused by steam and possibly to some extent by minute particles of KCN being driven off mechanically by the violence of the reaction.

forty minutes the dish and its contents were taken into the laboratory. A crystaline mass, chiefly bi-sulphate of potash, remained in the bottom of the dish.

The temperatures noted were as follows:

Temperature of air, 14°.*

Initial temperature of acid and water mixture, 110°

Temperature after 20 minutes, 48°

Temperature after 40 minutes, 32°

As the boiling point of prussic acid is 26½°, the final temperature was more than sufficient to volatilize it.

The contents of the dish were carefully washed into a 500 cc. flask and an aliquot part taken for the determination of the potassium cyanide remaining in the liquid. It was found that 5.7% of the cyanide had not been evolved. In other words, 5.72% (5.7÷99.7) of the available cyanide remained in the generating dish.

Another experiment identical in all respects, was made with an impure cyanide, one containing 49.35% KCN. During the reaction the only difference observed was that the clouds of prussic acid evolved were much more dense in color. An analysis of the resulting contents of the generating jar showed that they contained 5.07% potassium cyanide, or in other words, 10.27% of the available cyanide remained in the generating dish.

This effectually disposes of the assertion, sometimes made, that the residue remaining in the generator is harmless.† The reader can judge as to the poisonous properties of a mixture containing from 5 to 10% of potassium cyanide.

Experiment 2.—This experiment was carried on to ascertain something of the nature of the evolved gases. Necessarily smaller amounts of the cyanides were used, but the relative proportions were maintained. Thus, five grams of cyanide were used with 21 cc. of water and 10.5 cc. of sulphuric acid. The same cyanides used in Experiment 1 were employed.

No artificial heat was used, but only that evolved by the mixing of the acid and water. All determinations

*The temperatures given are in degrees Centigrade. To obtain the equivalent in the Fahrenheit scale multiply the number of degrees C. by $\frac{9}{5}$ and add 32.

†W. G. Johnson, in his "Fumigation Methods" (p. 11), advises pouring this residue around fruit trees "close to the trunk" in order that the potash may be utilized as a fertilizer. The excess of sulphuric acid in this residue will quickly destroy any living wood with which it comes in contact and such a practice is very likely to kill or seriously injure the trees. Other writers have made the same error.

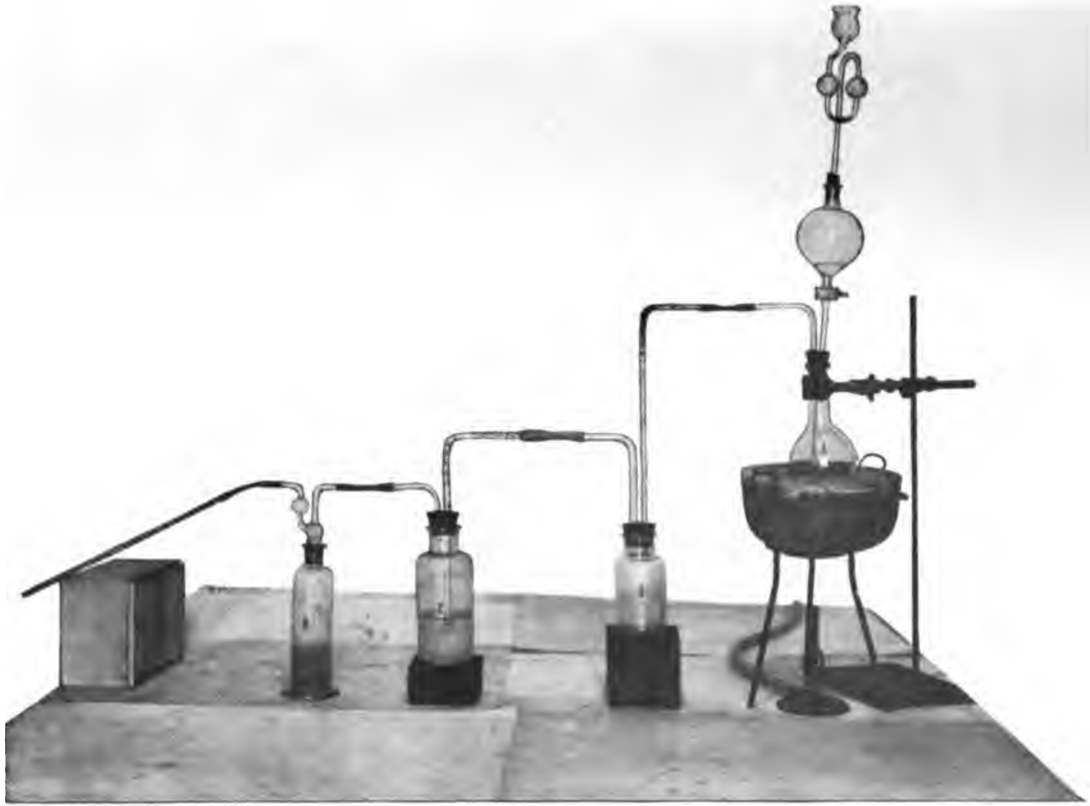

FIG. 1. Apparatus used for Collecting the Hydrocyanic Acid Gas Evolved from Potassium Cyanide.

were quantitative. An idea of the manner in which this experiment was carried out can be obtained by consulting Figure 1. The flask A was used for generating the prussic acid, the bottle B served as a guard and was empty, the bottle C contained more than enough nitrate of silver solution to absorb the prussic acid evolved, while D contained another solution of silver nitrate to absorb any prussic acid that might escape the solution in C.

In A was placed about 5 grams of the potassium cyanide and to this was added 21 cc. of water, without any attempt being made to dissolve the cyanide. From a separatory funnel provided with a safety tube to prevent any possible escape of gas, there was gradually allowed to flow into A 10.5 cc. of sulphuric acid. The gas evolved was passed by its own pressure at first, through the two solutions of silver nitrate in C and D. After the gas ceased coming off, air was drawn through the whole apparatus until every trace of prussic acid evolved had been passed through the silver nitrate. The silver cyanide thus produced was filtered off from the excess of silver nitrate, washed and determined quantitatively. The undecomposed cyanide in the generating flask A was also determined, and of course the difference between the sum of these two quantities and the total amount of cyanide in the original sample gave the amount of cyanide decomposed (lost) in the reaction. This loss was probably due to the decomposing action of the mineral acid with the consequent formation of ammonium formate. The following results were obtained:

The 99.7% cyanide gave:

Prussic acid evolved and available	35.92%,	equivalent to	86.47% KCN
" " not evolved	4.47%,	" "	10.76% KCN
" " decomposed and lost	1.03%,	" "	2.47% KCN

This indicates that 86.74% of the prussic acid is available for fumigating purposes and that 35.92% of prussic acid is evolved from the sample.

The 49.35% cyanide gave:

Prussic acid evolved and available	17.65%,	equivalent to	42.29% KCN
" " not evolved	.86%,	" "	2.07% KCN
" " decomposed and lost	1.99%,	" "	4.78% KCN

This shows that in this sample, 86.10% of the prussic acid is available and that 17.65% only is evolved.

In the case of the pure sample 10.8% (10.76÷99.7)

of the total cyanide remained unaltered, and in the case of the impure cyanide (49.35% pure) 4.2% of the total cyanide remained unaltered. As off-setting this, however, it will be noted that only 2.5% of the total KCN in the former was decomposed, whereas in the latter 9.7% of the total cyanide was decomposed and lost.

There is an apparent disparity between the amounts of cyanide remaining unaltered in this experiment and in the case of Experiment 1. It should be borne in mind, however, that in this experiment the acid was slowly added to the mixture of cyanide and water and the gas was evolved slowly, whereas in experiment 1 there was an excess of acid present during the reaction, instead of an excess of cyanide; also that the reaction was violent and of short duration at a time when the acid and water mixture was at its highest temperature. It seems likely that under the latter conditions considerable cyanide is removed mechanically from the generating dish by the violent ebulition.

It was thought that if a method could be devised whereby the cyanide could be added to the acid and water mixture, and the temperature maintained as near as possible to the temperature obtaining in the acid as ordinarily used in fumigating houses, this method would be more comparable with what actually takes place in a fumigatorium. It was of course impracticable to add the solid cyanide to the acid as is done in practice and attempt to collect the gas evolved. Such an attempt would also be decidedly dangerous to the operator. The method devised by Dr. Everhart and detailed in Experiment 3 is thought to be the closest possible approach to the conditions which actually exist when the cyanide is added to the acid and water mixture when fumigating nursery stock.

Experiment 3.—In this experiment the same apparatus was used as in experiment 2. In Experiment 1 it was found that the initial temperature of the acid and water mixture was 110 degrees, and although this temperature could not be exactly duplicated with the apparatus used, still the flask A was kept throughout upon a water bath, the water in which was kept boiling. The temperature therefore approximated 100 degrees while the gas was being evolved and the *average* temperature was doubtless as high as that of the mixture referred to in Experiment 1.

10.5 cc. of sulphuric acid were mixed with 13 cc. of water and the mixture was introduced into the generating flask A shown in figure 1. A solution of 5 grams of the cyanide sample was allowed to flow gradually from a separatory funnel into the hot acid. The separatory funnel was provided with a safety tube with a mercury seal to prevent the escape of gas. The prussic acid was passed through the bottles C and D as in Experiment 2, except that in this experiment C and D contained an ammoniacal solution of silver nitrate instead of a simple aqueous solution of that salt. For twenty minutes the gas was allowed to bubble through the silver solution from its own pressure, while the temperature was kept at the boiling point. The acid liquid was then allowed to cool while a stream of air was drawn through the apparatus to carry every trace of the evolved prussic acid into the silver solution.

Determinations were made of the prussic acid evolved and absorbed by the silver nitrate, of the potassium cyanide not decomposed by the sulphuric acid and remaining in the generating flask A, and of the sodium chloride of each sample which was also retained in the generating flask. Three samples were treated, one containing 99.7%, one containing 49.35% and one containing 103.4% of KCN. The latter sample was really composed largely of sodium cyanide but it is here mentioned in its equivalent of potassium cyanide.

The 99.7% potassium cyanide gave:

Prussic acid evolved and available	37.40%,	equivalent	to 90.05%	KCN
" " not evolved -	3.38%,	"	to 8.14%	KCN
" " decomposed and lost	.63%,	"	to 1.51%	KCN
Sodium chloride - - -	none			

This indicates that 90.31% of the total prussic acid is available and that there is 90.05% of available cyanide of potash in the sample.

The 49.35% potassium cyanide gave:

Prussic acid evolved and available	17.51%	equivalent	to 42.16%	KCN
" " not evolved - -	1.09%	"	to 2.62%	KCN
" " decomposed and lost -	1.90%	"	to 4.67%	KCN
Sodium chloride - - - -	12.71%	"	to 7.71%	HCl

This indicates that 85.41% of the total prussic acid is available and that there is 42.16% of available cyanide of potash in the sample.

The 103.4% potassium cyanide gave:

Prussic acid evolved and available	35.68%,	equivalent	to 85.91% KCN
" " not evolved - -	2.32%	"	to 5.60% KCN
" " decomposed and lost	4.94%	"	to 11.89% KCN
Sodium chloride - - -	12.35%	"	to 7.50% HCl

This indicates that 83.07% of the total prussic acid is available and that there is 85.91% of available cyanide of potash in the sample.

These results are perhaps more readily compared by reference to the following table:

TABLE II.

Sample	% Prussic Acid contained	% Sodium Chloride contained	% of Prussic Acid decomposed	% of Prussic Acid not evolved	% of Prussic Acid evolved and available
99.7%	41.41	0	1.52	8.16	90.31
49.85%	20.50	12.71	9.22	5.31	85.4
103.4%	42.94	12.85	11.50	5.4	83.07

By this method the pure cyanide yielded 3.57% more available prussic acid than by the method employed in Experiment 2. We are obliged to conclude that the method of adding cyanide to the mixture of acid and water is preferable to any method of adding the acid mixture to the cyanide. The order in which the water, acid and cyanide are brought together in ordinary practice evidently cannot be improved upon.

The most striking feature noticed in Table II is the greater decomposition of the prussic acid which took place when sodium chloride was present in the samples. This suggested further experiments to determine to what extent sodium chloride causes decomposition of the prussic acid evolved.

Effect of Sodium Chloride in Causing Decomposition of Prussic Acid.

In order to ascertain exactly to what extent the presence of sodium chloride and of nitrates in the cyanide of potash would cause decomposition of the prussic acid evolved, the following experiments were made:

Experiment 4. Merck's pure cyanide, intentionally adulterated with sodium cloride, was treated with sulphuric acid in the manner described in Experiment 3. The experiment was carried on under precisely the same conditions and with the same apparatus as was Experment 3.

Five grams of potassium cyanide (99.7% pure) were mixed with 15% of common salt. This mixture, dissolved in 8 cc. of water, was allowed to flow gradually into 10.5 cc. of sulphuric acid mixed with 13 cc. of water. The prussic acid evolved was passed through an ammoniacal solution of silver nitrate, and determinations made quantitatively of the prussic acid evolved and available.

The following results were obtained:

Prussic acid evolved and available	35.50%,	equivalent	to 81.53% KCN
Total prussic acid in sample -	43.42,%	"	to 99.7 % KCN
Prussic acid decomposed - -	7.92,%	"	to 18.17% KCN

Experiment 5. Another experiment, using the same amounts of acid, water and potassium cyanide, while the percentage of sodium chloride was increased to 16.23%, gave the following results:

Prussic acid evolved and available	34.15%,	equivalent	to 78.42% KCN
Total prussic acid in sample -	43.42%,	"	to 99.7 %. KCN
Prussic acid decomposed - -	9.27%,	"	to 21.28% KCN

Experiment 6. Still another experiment was made, using 5 grams of the 99.7% cyanide mixed with 9.91% of sodium nitrate dissolved in 8 cc. of water. This was allowed to flow into a mixture of 10.5 cc. of sulphuric acid and 13 cc. of water. The results were as follows:

Prussic acid evolved and available	39.52%,	equivalent	to 87.04% KCN
Total prussic acid in sample -	43.42%,	"	to 99.7 % KCN
Prussic acid decomposed - -	3.90%,	"	to 12.66% KCN

To state these results in another way, bearing in mind that sodium chloride coming in contact with sulphuric acid yields free hydrochloric acid and that sodium nitrate under the same conditions yields free nitric acid, it appears that the presence of

9.36% HCl (15% NaCl), causes the loss of 18.17% KCN
10.13% HCl (16.25% NaCl), causes the loss of 21.28% KCN
7 34% HNO_3 (9.91% $NaNO_3$), causes the loss of 12.66% KCN,

whereas, by using the same cyanide (99.7% pure), without chlorides or nitrates present, but 1.51% KCN is decomposed (See Experiment 3).

It is obvious that the presence of any foreign substance in the cyanide of potash, which upon the addition of sulphuric acid will liberate a second mineral acid, will result in greatly diminishing the amount of available prussic acid.

Amount of Available Prussic Acid Not Necessarily Proportionate to the Amount of Cyanogen in a Given Sample of Potassium Cyanide.

The question is not infrequently asked by nurserymen whether or not an inferior cyanide, the cyanogen content of which is known, can be used in sufficiently large quantities to secure the exact amount of hydrocyanic acid gas required; whether, for example, two ounces of a 49% cyanide or three ounces of a 33% cyanide cannot be safely substituted for one ounce of 98% cyanide. In general, the question must be answered in the negative. The exact amount of prussic acid available from a sample of potassium cyanide can be determined only by a process the same, or similar to, the one used in Experiment 3. If we consider each per cent. of available prussic acid as a unit, then it is clearly seen that two ounces of the "49.35%" cyanide used in Experiment 3, will yield 35.02 "units" of available prussic acid instead of 37.4 units as would be expected (that is, the number of units obtained from the 99.7% cyanide). With the impure cyanides the difference between the amount of available prussic acid actually secured and that which should theoretically be secured, will vary with the amount of sodium chloride (or other mineral acid) used as an adulterant. In the case of a "60%" cyanide, for example, the question naturally arises: "What makes up the other 40%?" We have found sodium chloride present in low-grade cyanides and it is perhaps the cheapest adulterant that can be used. Our experiments have also shown that the greater the amount of sodium chloride present, the greater the loss of available prussic acid.

Even in the case of cyanides which show a high analysis—which contain cyanogen equivalent to 98% or over of KCN—the amount of prussic acid available is not *necessarily* proportionate to the cyanogen shown by analysis. The "103.4%" cyanide used in Experimeut 3 offers an illustration. Taking the 99.7% chlorine-free cyanide (one ounce of which yields 37.4 "units" of available prussic acid), as a basis, one ounce of the "103.4%" cyanide *should* yield 38.78* units ot available prussic acid, when as a matter of fact it yields but 35.68† This difference of 3.1% available prussic acid is of course equivalent to 7.5% "available" KCN or 8.3% of "total cyanide." Expressed in still another way, this "103.4%" cyanide is, so far as its use for fumigating purposes is concerned, equivalent to a cyanide of the same quality as Merck's which analyzes 95.11%.‡

How Can the Nurseryman Be Sure of Obtaining Pure Cyanide of Potash?

The reader who has carefully perused the foregoing may feel inclined to ask this question. We must admit that in view of the many inferior cyanides upon the market and the presence ot adulterants in still other cyanides which show a "high analysis," the question is rather a perplexing one. For the present at least, we can offer but one solution. In the investigations made of various cyanides upon the market§ we have found only

*Obtained by the proportion: 99.7 : 37.4 :: 103.4 :?

†The criticisms in this bulletin relative to cyanides should be understood as applying to these cyanides only when used for fumigating nursery stock. In other commercial uses, as for example in the cyanide process of extracting gold, where very dilute solutions of the cyanides are used. it is not likely that sulphuric acid would cause any appreciable decomposition. In fumigating buildings or cars for the purpose of destroying obnoxious insects, the decomposition of the prussic acid is not of such importance, as a considerable excess of cyanide can be used to insure a gas sufficiently strong. In fumigating nursery stock, however, the margin between the strength of gas necessary to be thoroughly effective against scale-insects and the strength which is injurious to plants, is not great, and hence it is desirable that the exact amount of prussic acid used should be known.

‡Also obtained by the proportion: 90.05 : 85.91 :: 99.7 :?, or 90.05 : 99.7 :: 85.91 :?

§Table I does not represent all of the cyanides which we have examined. Other samples have been so manifestly inferior that a chemical examination was entirely unnecessary to establish that fact.

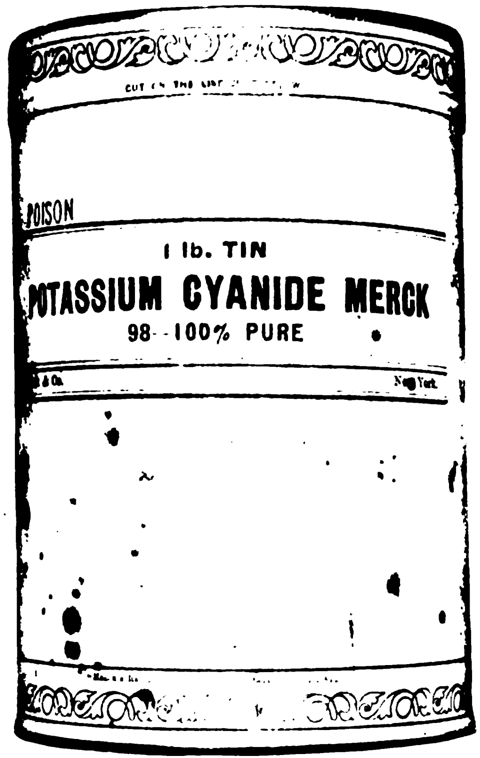

FIG. 2. An original one-pound package of Merck & Co.'s "98–100%" Potassium Cyanide.

FIG. 3. Original one-pound bottle of the Baker & Adamson Chemical Co.'s "99%" Potassium Cyanide.

two that fulfill all the requirements and that can be considered as thoroughly reliable for fumigating nursery stock. One of these is Merck & Co.'s "98-100%," and the other is the Baker & Adamson Chemical Co.'s "99%" cyanide*. Both these were found free from adulterants and fully up to the standard of purity guaranteed by the manufacturers. The nurseryman should always insist upon receiving these cyanides *in original sealed packages.* The sealed cans or bottles containing the cyanide should not be opened or tampered with between leaving the factory and being opened by the nurseryman for immediate use. Exposure of the cyanide to air for any considerable time will permit of its absorbing moisture, with consequent deterioration. The only way in which the nurseryman can be *sure* of obtaining pure cyanide, is by purchasing one or the other of the above-mentioned brands, in original sealed cans or bottles. To enable nurserymen to more readily identify these two brands, photographs of original one pound packages are shown in Figures 2 and 3.

Temperature Necessary for Evolution of the Prussic Acid.

Experiment 7. Four fluid ounces of water at 20° were mixed with two fluid ounces of sulphuric acid (Sp. G. 1.84) also at 20°. The initial temperature of the mixture became 110° and this may be considered as the temperature actually secured in ordinary practice when the regular "1-2-4" formula is used. Into this mixture at 110° was placed one ounce of 98% cyanide and the extire mixture exposed to the outside air (having a temperature of 14°), for forty minutes. At the end of this time the mixture still had a temperature of 32°. As the boiling point of prussic acid is 26½°, the temperature throughout the entire forty minutes was sufficient to volatilize the prussic acid.

When four ounces of water were mixed with one ounce of acid, a temperature of but 81° was secured and while this is still far above the boiling point of prussic acid, it is very doubtful if the temperature of the mixture would be above 26½° at the end of forty minutes. Two

*There may of course be other cyanides upon the market which will meet all requirements for fumigating purposes, but we have exercised reasonable diligence in searching for them and our efforts have not met with success.

ounces of water and one of acid would of course give an initial temperature of 110°, but owing to the reduced volume of the mixture the introduction of the one ounce of cyanide would cause a much greater reduction of temperature than when the two ounces of acid and four of water are used. It is also very probable that as much as four ounces of water are necessary to properly dissolve the potassium bisulphate formed, in order to prevent this bisulphate from forming a deposit about the KCN, thereby reducing the amount of prussic acid generated.

The mixture of four ounces of water and two of acid, to each ounce of cyanide, meets every requirement in that it permits volatilization of an apparently maximum amount of prussic acid, and we do not consider a change to a more dilute acid or to a lesser amount of water and acid as advisable.

CONCLUSIONS.

1.—Failure to obtain satisfactory results in fumigating nursery stock has in many cases been due to the use of impure or adulterated cyanide, which is often represented and sold as being pure.

2.—In generating the gas, a somewhat greater amount of hydrocyanic acid gas is obtained when the cyanide is added to the mixture of acid and water, than is obtained when the acid and water mixture is added to the cyanide. The former method, which is ordinarily practiced, is therefore preferable.

3—The presence of sodium chloride (common salt) in the potassium cyanide causes decomposition and loss of hydrocyanic acid gas and hence a reduction in the amount of gas actually available for destroying insects. The greater the extent to which the cyanide

is adulterated with chlorides or nitrates, the greater the loss of hydrocyanic acid gas.

4.—The most common adulterant in low-grade cyanides is likely to be sodium chloride and hence, owing to the loss of hydrocyanic acid gas by decomposition, increased amounts of low-grade cyanides cannot be safely substituted for pure cyanide when fumigating nursery stock.

5.—When sodium chloride occurs in a "high-grade" cyanide, the amount of potassium cyanide indicated by a chemical determination of the cyanogen present is not proportionate to the amount of available hydrocyanic acid gas obtainable from such cyanide. In other words, a chemical analysis showing a high percentage of potassium cyanide in a given sample, is not wholly reliable unless such analysis also shows the absence of chlorides, nitrates, etc.

6.—Of the different cyanides examined, only two, Merck & Co.'s "98-100%" and Baker & Adamson Chemical Co.'s "99%", were found to meet all the requirements of a cyanide for fumigating nursery stock. Nurserymen are therefore advised to use one or the other of these two brands, purchasing them only when in original sealed packages.

7.—The temperature secured by the mixture of two fluid ounces of sulphuric acid (specific gravity 1.84) and four fluid ounces of water produces apparently

the maximum volatilization of the hydrocyanic acid gas evolved from one ounce of cyanide, and the alteration of this proportion or a reduction of the volume of acid and water used appears undesirable and unnecessary.

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The Cotton Boll Worm in Georgia.

Insects Injurious to Corn and Truck Crops.

BY

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CAPITOL BUILDING, Atlanta, Ga.

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To the Honorable Board of Entomology of the State of Georgia:

I have the honor to submit the accompanying manuscript for publication and distribution in accordance with an Act of the General Assembly, approved December 20th, 1898.

This manuscript has been prepared to offer practical suggestions to cotton and truck growers, for the control of a few of the more common injurious insects that appear every year in Georgia. It is not intended to be a report on the result of investigations carried on by this Department, except in a few instances, as it is practically a compilation of facts known to nearly all entomologists about the insects mentioned herein, with suggestions regarding the best remedial measures.

It is hoped that this work will prove to be of practical value to the general farmer.

Very respectfully,

Approved: R. I. SMITH.

O. B. STEVENS, Chairman of the Board.

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BULLETIN

OF THE

Georgia State Board of Entomology.

APRIL, 1905. *No. 16.*

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THE COTTON BOLL WORM.

(*Heliothis armiger.*—Hubn.)

Injury from this insect has long been familiar to all cotton growers in Georgia, as well as the entire south. Its regular appearance in greater or less numbers each year has caused growers to give but little attention to the injury caused by the boll worm. By referring to back records we find that the boll worm was reported as being quite destructive in Georgia in 1899. Prof. A. L. Quaintance, reporting from the Georgia Experiment Station on insects of the year, says, "The boll worm has been more than usually destructive * * * the second brood practically destroyed early tomatoes and sweet corn * * * by the middle of July complaints from cotton growers began to be heard * * *." Since that time it has appeared at various places in Georgia each year. In 1903 it was reported as doing considerable damage; and in 1904 reports of its boring into cotton squares came in frequently during the month of June, and at various times during July and August. The fact that boll worm injury was reported so early in the year in 1904 makes it seem advisable to mention it quite prominently at this time. In the following paragraphs it will be seen that boll worm injury to cotton is not common until about August 1st, when its favorite food plant, corn, has become hard and distasteful.

The boll worm appeared in considerable numbers in Georgia during 1904, in the following counties: Randolph, Pulaski, Dooly, Upson, Meriwether, Decatur, Jackson, Richmond and Glascock. In Dooly county it was charged with destroying 50 per cent. of

the cotton squares in several fields, and in several instances the damage was thought to be caused by the Mexican cotton boll weevil. These reports of the supposed boll weevil proved in all cases, upon investigation, to be the work of the cotton boll worm.

Besides feeding on cotton the boll worm is often a serious pest on corn, tomatoes, beans, peas, okra and tobacco. The latter crop is injured by having the buds eaten. All the other crops mentioned are injured by the boll worms boring into the fruit, or in the case of beans and peas, into the pods.

The Insect Described.

The boll worm belongs to the class of insects that have four distinct stages in their development, namely: adult, egg, larva and pupa. The adult is a moth which commonly flies in the night, but when disturbed during the day-time they fly with a quick darting motion that is quite characteristic. The moths vary in size, but in general they have a wing expanse of about one and one-half inches. The color may also vary greatly, ranging from a dull yellow to a dull olive-green with numerous dark spots and markings on the wings. These moths may be easily distinguished from the cotton leaf-worm, or caterpillar moth by the fact that when at rest the boll worm moth holds its wings slightly raised and parted to expose a portion of the body, while the cotton caterpillar moths always rest with the wings tightly closed. The accompanying figure shows the general shape and size to good advantage. (Fig. 1.)

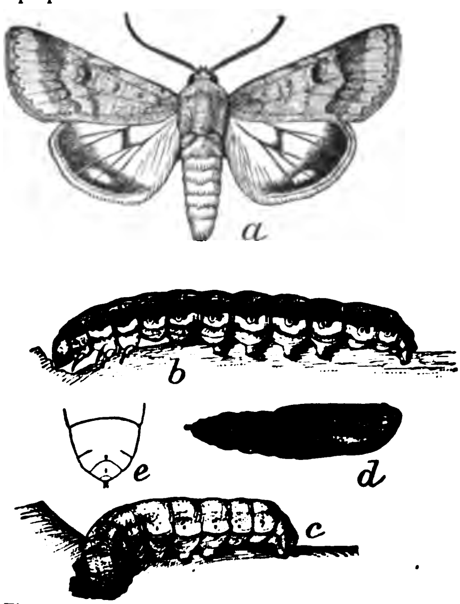

Fig. 1.—Cotton Boll Worm: a, adult moth; b and c, larvae; d, chrysalis or pupa; (After Howard, Yearbook, U. S. Dept. of Agr., 1898.)

Moths usually appear in spring about the time that [redacted]s ten or fifteen inches high,* and in general they prefer to deposit eggs on young corn instead of cotton, the eggs being laid on all parts of the plant, but a preference is shown for silk if it is present.

The eggs are small, oval in shape, whitish or yellow in color, and may be seen with the unaided eye. Each female deposits on an average 1,100 eggs. These eggs hatch in from 3 to 10 days, depending on the season.

From these eggs minute worms are hatched which are at first pale green in color, but soon become darker. The full grown larvæ may vary in color from pale green to brown or almost black. These worms are voracious feeders, a single individual often destroying a large number of squares or bolls. This habit of going from one place to another on the plant, for the purpose of feeding, explains the reason why the farmer finds many young squares with a hole in the base but no sign of the transgessor. (See Fig. 2.) Boll worms when first hatched wander around on the plant feeding on the leaves until they find a square or form into which they bore. It is during this time that the worms may be poisoned with arsenicals. A full grown boll worm measures from 1¼ to 1½ inches in length,

Fig. 2.—Cotton squares destroyed by Boll Worms. (Original.)

* Quaintance & Bishop, U. S. Dept. Agr. Farmers Bul. 212.

(see Fig. 1) and they may complete their growth during the summer season in about fifteen days.

When full grown the worms descend into the ground where a cell is constructed in which the pupal stage is passed. This period usually covers about two weeks on the average. From the pupa there emerges the adult moth, as already described, ready to mate and deposit eggs for the next generation.

In Georgia there are at least four and possibly five generations, so it will readily be seen that if the boll worms confined their attacks from the first to cotton the damage would be tremendous. In general it may be said that the third brood is the one that injures cotton most severely, or at least that has been the generally accepted belief in the past. Last year, however, in 1904, a majority of reports from boll worm injury came to the entomologist during June and July, which showed that it must have been the larvæ of the first and second broods that were doing the damage.

Remedies and Prevention.

Of the two, prevention is the best, but for the protection of this year's crop, if the boll worms appear, the remedy must be considered. There are two main methods of preventing injury to cotton. The use of corn planted in rows through the cotton field to serve as a trap, and the application of arsenical poisons to destroy the worms when on the cotton.

Corn as a trap plant should be planted in rows every 200 or 300 feet throughout the entire field. This corn should be planted late, about the middle of May or June 1st, so as to be in prime silking condition about August 1st. As the boll worm moths seem to prefer corn to cotton most of the eggs will be deposited on the corn, which can be destroyed or fed to stock when the worms are partly grown. If an early maturing variety of corn is planted about May 1st, and more of the same variety planted about June 1st, the planter will always have an attractive plant for the moths during the period when they are expected to be most abundant. Cowpeas should be planted between the corn rows in time to be in bloom when the corn is in silk. The blooms will attract the moths.

Poisoning should be attempted when the worms first appear on the cotton. Experiments in Texas by Prof. A. L. Quaintance

in 1904 showed that it will pay well in most cases to poison for the third brood. In Georgia, as the worms of the second brood do so much damage, it will probably be found advisable to poison as soon as the first worms appear on the cotton. This will be about June 1. The old method of applying poison by means of the simple dusting apparatus carried by a man who walks rapidly along the

Fig. 8.—Method of applying Paris green in dry form to cotton plants. (Photo by Wilmon Newell.)

row dusting both sides of the plant at once (See Fig. 3) has proved to be most economical. This fact was demonstrated by Prof. Wilmon Newell in 1903, and reported upon in his Bulletin No. 9, of the Georgia State Board of Entomology on "The Cotton Caterpillar." He found the best way to apply the poison was to mix it with fine lime dust—cheap flour can be substituted—used

in the proportion, 1 pound of Paris green to 4 pounds of dust. This should be applied so as to put at least 2 pounds of the Paris green to each acre. Owing to the fact that the boll worms feed to some extent on the leaves and pass frequently from one place to another even when working on the squares and bolls, it is possible to destroy large numbers with the use of poison.

Possibly the most valuable and economical way of fighting the boll worm is to plow the land during the fall and winter, thus breaking up the pupal cells in which the winter is passed. It has

Fig. 4.—Dusting apparatus for applying Paris green to cotton plants.

The dusting apparatus shown in Fig. 4 is made from a one inch board, 4½ feet long and three inches wide, by boring an inch and a half auger hole five inches from each end, and attaching under each hole a sack five inches wide by about fifteen inches long. These sacks can be made from unstarched sheeting running about 4 pounds to the yard. If it is found that the poison is being applied too fast or too slow the proportion of lime, or flour and Paris green, must be changed so that the required amount of actual poison will be applied per acre.

been found that nearly all the pupa thus disturbed will die during the winter. This practice should be followed in all sections where the boll worm is known to occur. This is also a valuable way of fighting many other insects such as Corn Stalk Borers, Grub Worms, Squash Vine Borers, and all insects that pass the winter under ground.

Attacking Other Crops.

As already mentioned, tomatoes are often injured by boll worms, though when occurring on tomatoes they are generally known as "tomato fruit worm." The damage is caused by the worms boring into the green and ripening tomatoes, in which large excavations are often made. When occurring on tomatoes the worms usually have to be picked off by hand. Poison in liquid form, as recommended further on for cotton caterpillar, may be applied while the plants are small. The worms frequently bore

into the stems of tomato plants at first, but soon transfer their attacks to the fruit. Winter plowing of gardens will aid in keeping this pest in check.

Corn injured by boll worms should be cut and fed to stock to destroy the larvæ and the eggs which may be present. Early corn is most liable to be infested and a strict cleaning out of all infested plants during June and July will greatly reduce the numbers of the following broods.

When peas and beans, that will be shelled before using, are attacked, the poison in the form of arsenate of lead or Paris green and lime mixture is recommended.

THE COTTON CATERPILLAR.

(*Aletia argillacea*—Hubn.)

This enemy of cotton is mentioned here, and figures presented principally to show the difference between it and the boll worm. In 1903 the ravages of the cotton caterpillar were severely felt in a few counties in Middle and South Georgia, but reports from its injury in 1904 were very few, and in fact, the injury was not sufficient to cause any concern among cotton growers.

Fig. 5.—Cotton Caterpillar Moth: a, wings expanded; b, wings closed, at rest. (After Riley, Fourth Rept., U. S. Entom. Comm.)

The main points of difference to be noted between the cotton caterpillar, or leaf worm, as it is sometimes called, and the boll worm, is in their mode of injuring the plant. While the boll worms feed to some extent on the foliage, the cotton caterpillars feed entirely on the leaves and buds unless in extreme cases where the plant is entirely defoliated. At such times they may gnaw into the squares and green bolls, but seldom do much injury in this way. Figure 5 shows the adult caterpillar moth, which may be compared with the boll worm moth. Fig. 6 represents full grown caterpillars. Unlike the boll worm the caterpillar does not go

into the ground to pupate. This stage is passed in a folded leaf on the plant. There are always several generations each year and as the complete life cycle from egg to adult may be covered in from three to four weeks, it is evident that the increase may at times be very rapid.

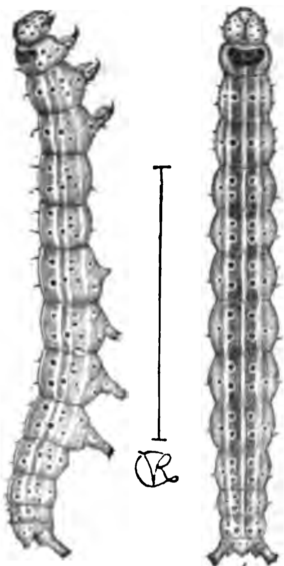

Fig. 6.—Cotton Caterpillar: a, from side; b, from above; twice natural size. (After Riley, Fourth Rept., U. S. Entom. Comm.)

Remedy.

The remedy is the same as recommended for boll worms in regard to poisoning. The plants should be watched closely and poison applied while the caterpillars are small—as they are more easily killed then—and the injury to foliage avoided. Dusting with Paris Green and lime dust should be done during the early morning hours, as it will adhere better to the plants at that time. In wet weather dust is frequently washed off by rains. and in that event we would advise the use of Paris green in water, using a formula,

1 pound Paris green,
2 pounds stone lime,
100 gallons water.

Or in place of the above, arsenate of lead (Disparine) may be used at the rate of 3 pounds to 50 gallons of water. The latter will adhere somewhat better than Paris green mixture, but cannot always be as readily obtained when needed at short notice.

DIRECTIONS FOR MAKING ARSENATE OF LEAD.

Dissolve 11 ounces of Acetate of Lead in 1 gallon of water, and 4 ounces of Arsenate of Soda in ½ gallon of water. Stir these two solutions together. The resulting mixture will be Arsenate of Lead which will appear as a light flocculent precipitate, which will readily remain in suspension. This may be diluted to make 50 gallons for ordinary use. It will be found that arsenate of lead will adhere to foliage longer than most other arsenicals.

Disparine is a manufactured preparation of Arsenate of lead, which is sold in the form of paste and will readily dissolve in cold water. It costs a little more than the home-made article but will be preferred by many as it comes ready to use.

Swift's Arsenate of Lead is a comparatively new preparation that is now on the market. It contains a high per cent. of glucose, which is claimed to help its adhesive property; it is known to be a good insecticide.

THE CORN STALK BORER.

(*Diatraea saccharalis.*—Fab.)

Fig. 7.—Corn stalk showing holes made by corn stalk borers. (Original.)

This enemy of corn has been known since early in the nineteenth century, as it was described by Rev. Lansdown Guilding in 1828,* who reported its presence in sugar-cane in the Island of St. Vincent in the West Indies. Dr. Howard concludes that it must be a native of the West Indies or of South America where the cultivation of sugar-cane was first begun in America. In 1855 this pest was reported as injuring sugar-cane in the State of Louisiana, and in 1881 we learn that the U. S. Division of Entomology made observations on the ravages of this pest in Louisiana, where it was severely injuring sugar-cane. In Georgia it was found in Lincoln County in 1880, and was reported from South Carolina about the same time. In 1881 the corn stalk

* Dr. L. O. Howard, Insect Life, Vol. IV, p. 95.

borer was found doing considerable injury to corn in a large field near Atlanta. It was probably some years previous to this date that the borer began to attack corn as well as sugar-cane. Since 1881 it has been reported at times from various points in Georgia, but the records at hand concerning it are very meagre.

During the month of June, 1904, the corn stalk borer appeared in alarming numbers in the vicinity of Hawkinsville, Georgia. Specimens of the insect and its work were sent to this office by Mr. C. C. Atkinson early in June, and as he reported such extensive injury an investigation was made at once.

On June 20th the writer visited Mr. Atkinson's plantation and found the borers very abundant in a large field of corn near the house. Other fields in the vicinity were examined and in all such borers were found in considerable numbers. In some instances as many as five and six borers in a single stalk of corn and the large number of holes made by each borer made it look as though many more might have been present. (See Fig. 7.)

Life History and General Appearance.

The corn stalk borer is a white six-footed larva attaining a size when full grown of about one inch in length (See Fig. 8). The winter is passed in the pupa stage embedded in the corn stubble near the surface of the ground. Early in spring the moths issue from the over-wintering pupæ and when the corn is only a few inches high the eggs are deposited on the stem and leaves. These eggs hatch in a short time into small borers which at once commence to tunnel into the stalk and up through the pithy center. The injury may be quite considerable and may even necessitate replanting.

Observations made by the writer show that some of the borers of the first brood may attain full growth by the first week in June. The change to the pupa at once takes places, usually in the stalk above ground, and adult moths emerge at least as early as the middle of June in the vicinity of Hawkinsville. Moths continue to issue until about the middle of July.

Corn stalk borers are very active and pass frequently in and out of the stalk in which they are working, thus making a large

number of holes. The accompanying figure shows the appearance of a corn stalk in which borers were at work. Most of the damage is confined to the three lower joints, but in a few cases larvæ and pupæ were found three feet up in the stalk. Figure 9 shows the larva or borer, and pupa about twice natural size.

Fig. 8.—A corn stalk cut open showing borers within. (Original.)

The adult corn stalk borer is a delicate looking moth, fore wings dull yellowish brown, in some cases having very little color. The males in all cases have the fore wings a little darker than the females, and the former are always somewhat smaller in size. Wing expanse varies from a little over one inch to a little more than one and one-half inches. The hind wings are always clear white or cream color.

The writer is informed by Mr. Betts, of Hawkinsville, that the corn stalk borer injured his corn in 1900 to an extent of 50 per cent. He has observed that the injury is greatest during

dry seasons, as 1900 was very dry, as was also the season of 1904.

Borers may occur in corn stalks without seeming to injure the yield, but usually a certain per-cent. of the stalks are destroyed while the corn is still small. This injury should be guarded against, and can be largely averted by following the suggestions given in the paragraphs on Remedies.

Fig. 9.—Larva and pupa of corn stalk borer. On left, larva; on right, pupa—twice natural size. (Original.)

Remedies.

Considering the habit of the corn stalk borer it is evident that the damage cannot be stopped after the borer has once gained access to the stalk, without at the same time destroying the corn. It is not practical to remove the borers, unless from a few stalks of corn in the garden, as is recommended for the squash vine borer. It is clearly apparent that corn following corn year after year is most liable to infestation because of the number of borers that winter over in the old stubble. The usual practice in Georgia of allowing the corn stubble to remain on land is the principal cause of the bad invasions of stalk borers; along this same line rotation of crops offers a relief from the pest. This is an old suggestion, but it remains good.

In infested fields all corn stubble should be gathered and burned to destroy the pupa that are wintering therein. Deep plowing in early spring to bury all stalks that were not gathered will be advantageous. The pupa should be buried so deeply that the emerging moths cannot escape.

If rotation of crops, burning stubble and deep plowing are practised, corn stalk borers can generally be successfully controlled.

CORN ROOT WORM.

(*Diabrotica* 12-*punctata*.—Oliv.)

Corn is often attacked by a root worm soon after the plants

appear in the spring. The injury is caused by the larva of a beetle that is common in the South and known as the twelve-spotted Diabrotica, the scientific name being *Diabrotica 12-punctata.* To farmers it is locally known as "bud worm" on account of its causing the bud to wilt when the roots are attacked.

The adult Diabrotica is a green beetle (See Fig. 10) about one-third to one-half inch in length, oblong in outline, tapering toward the anterior end, and having three transverse rows of four black spots on the wings. The adults often feed voraciously on melon, squash and cucumber, and they have been known to feed on almost every farm crop imaginable. In fact, they are practically omniverous.

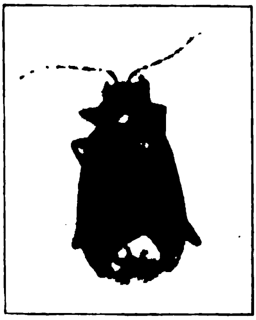

Fig. 10.—Adult beetle, parent of corn root worm (enlarged). (Original.)

These root worms have been found to injure corn in bottom lands most severely, and especially early plantings. Corn planted after May 5th to 10th is seldom injured severely, as most of the eggs are deposited previous to that time. When corn is planted early a surplus of seed can be used and in most cases enough plants will be uninjured to insure a full stand without re-planting. A simple rotation of crops will usually suffice to prevent injury from corn root worms. Corn following wheat, rye, or barley is seldom attacked, and the land will generally remain free from root worms for at least two years.

The suggestion that corn can be treated so as to become distasteful to corn root worms, was shown to be worthless by Quaintance in 1900.* So also was the use of kainit as a fertilizer in killing the larvæ. In one case he found root worms even worse where kainit was applied.

Melons, squash and cucumber plants attacked by the adult Diabrotica should be dusted with land plaster and Paris green in the morning while the plants are wet with dew. As this insect eats large holes in the foliage the use of poison will be found advantageous.

As a matter of interest it may be stated that the 12-spotted Diabrotica has often been charged with spreading diseases, such

* U. S. Dept. of Agr., Div. of Ent., n. s. Bul. 26.

as the pear blight, by visiting the blooms and carrying the blight bacillus from one point to another.

THE SQUASH VINE BORER.

(*Melittia satyriniformis.*—Hubn.)

Like the corn stalk borer this insect does its damage by burrowing in the stalks of its host plant. Its injury is confined mainly to squash and pumpkins, but melons, cucumbers, etc., may be attacked. The adult moth, parent of the borer, is one of our most beautiful species, and described by Quaintance* as having fore wings opaque, shining olive brown in color, with metallic green reflections; the hind wings transparent with a narrow fringe of scales. Hind pair of legs are thickly fringed with hairs, which on the inside are black, and on the outside orange colored. The body is about three-fourths of an inch long and the wings may expand one and one-fourth inches. (See Fig. 11.)

Fig. 11.—Moth, or parent of the squash vine borer. (After Quaintance, Ga. Ex. Sta. Bul. 45.)

The moths appear about the middle of May and deposit eggs on various parts of the plants, mainly along the stem, as determined by Quaintance. Eggs hatch in from six to fifteen days and the larvæ attain full growth in about one month.

Observations made by the author during 1904 show that the

* Ga. Exp. Sta. Bul. No. 45, p. 47.

second brood of adults may begin to appear by July 1st in South Georgia. On June 17th, 1904, summer squash vines were found at Chester, Ga., containing the larvæ, one or two in each plant. On July 4th these plants were again examined when it was found that all the burrows or channels in the stalks were empty. By digging down around the plant the tough silken cocoons were found, in one case four at the base of one plant. As not more than two larvæ were observed in a single plant June 17th, it seems probable that some had already gone into the ground before that date. On July 4th a few empty cocoons (See Fig. 12) were found, showing that some adults had already emerged. From pupa secured at this date adult moths were emerging up to July 11th. From these notes it appears that the pupal stage covers from three to four weeks.

Fig. 12.—Pupa and empty cocoon of squash vine borer —twice natural size. (Original.)

How to Detect Presence of Squash Vine Borers.

During the latter part of May and the first part of June examine the vines and if there are any accumulations of yellowish excrement around the stem, carefully cut open the stem and remove the white grub-like borer. This will often save the plant without much injury resulting from cutting. The injury is caused by the borers making large channels in the stem (See Fig. 13), and often causing the whole plant to shrivel and die. Ordinary insecticides and repellants are of very little use. The grower must watch closely and remove the borers when they are present. After the crop is gathered the vines should at once be pulled and burned to destroy all borers of the second brood.

Fall plowing and harrowing the gardens will destroy many pupæ; this coupled with clean culture and destruction of infested stalks will result in keeping the borers in check in most cases.

Fig. 13.—A squash stem cut open showing the borers within. (After Quaintance, Ga. Exp. Sta. Bul. 45.)

Cutworms may easily be classed as one of our most injurious species of insects. Working silently in the night, as they do, a vast amount of injury may occur before the damage is discovered. A knowledge of the life history and habits is necessary in order to understand how to fight this pest.

Life History—The adult cutworm moths appear during the months of June and July, and soon after arrival begin to deposit eggs on the grass, weeds and rubbish. A grassy sod may be selected as the place to deposit eggs or any field where there is an abundance of grass and weeds. Eggs hatch in a short time and the young cutworms, at first very small, begin to feed on any succulent vegetation at

hand. At this time of year they are so small and the food so abundant that the injury caused is not noticeable. By the time cold weather approaches the cutworms may be in all stages of maturity, from one-half inch in size to nearly full grown. So far no noticeable injury has occurred. Cutworms pass the winter in little earthen cells in the soil under rubbish, stones or any protected place.

In the spring when the land is plowed the cutworms, emerging from their winter quarters with ravenous appetites after their long winter fast, begin to feed on any vegetation at hand. It is therefore evident that the first plants to come up in the garden will be liable to be cut off by the little cutworms.

Description—The adults of our cutworms are moths belonging to the family, *Noctuidae,* meaning night fliers, and for that reason they are seldom seen unless attracted to lights. Moths range in size from one and one-half to two and one-half inches in wing expanse. Color of front wings dark brown or grey; hind wings always lighter than fore wings. Cutworms have naked bodies, eight pairs of legs, three in front and five at the posterior end of the body; color may vary from dirty green to grey or dirty brown. Full grown worms average one and one-half inches in length.

Remedies—Injury from these insects may be largely prevented by any or all of several methods. First of all should be mentioned fall plowing to expose the pupal cells in which cutworms pass the winter. This should be practised in fields where cutworms have been numerous. Second, poison the cutworms in the spring with poisoned bran-mash or clover, before the crop is planted. This can be accomplished by fitting land a few days previous to the time when seed is to be sown. For poisoned bran-mash use one pound of Paris green, forty pounds of bran, two quarts of molasses and mix this with just enough water to make a thick dough that can readily be made into balls. This mash may be placed on the land in little heaps just before night-fall. The cutworms being deprived of all other food, if the land has been fitted as suggested, will readily eat the mash while it is fresh.

Another very good plan is to spray a small piece of succulent clover with Paris green, one pound to twenty-five gallons of water, cut the clover, and spread it on the land before it has time

to wilt. This should be done about sun-down and such bait will be very attractive to the cutworms. It is almost worthless to attempt to poison cutworms after the crop is up, or if there is much grass or weeds on the land.

When tomatoes, cabbages and the like are to be transplanted fit the land several days in advance, let it remain untouched for two or three days, in order that the cutworms may become hungry, and then try poison bait for three nights in succession. Newly plowed sod land should always be treated in this way for reasons already stated. No rubbish or weeds should be left on land after the main crop is removed as it furnishes food for the cutworms during the fall months and protection during the winter.

As some people object to the use of poison bait on account of liability of poisoning poultry and other animals, bands of tarred paper are recommended for use around such plants as cabbage and tomatoes. This paper may be pushed into the ground around each plant to a depth of at least one inch so that the cutworms will not crawl underneath. This will protect the plants while small and the bands may be removed after a few weeks and used around other plants.

SQUASH BUG.

(*Anasa tristis*.—DeGeer.)

This is the rather large, flattened rusty black bug which injures squash and other cucurbits. This insect has a sharp, pointed beak, through which it draws the sap from the plant. Infested plants become yellow, and sickly and often die.

Remedy—Hand picking of adults when they first appear is recommended. They may also be trapped under pieces of board, or leaves from the plant, laid on the ground and examined each morning.

The eggs are laid in masses on the under sides of the leaves and are readily seen owing to the yellow color. These egg masses should be found and destroyed. If any hatch, the young will be found feeding in groups. These may be crushed between the fingers. Attention to these minor details will usually be the means of preventing serious injury.

Clean cultivation of gardens, keeping all weeds, trash and

vines removed, will cause many squash bugs to succumb to the winter weather.

THE CUCUMBER BEETLE.

(*Diabrotica vittata.*—Fabr.)

This is the little yellow black-striped beetle that feeds on the young cucumber and melon vines and damages them badly at times by eating small holes in the leaves. This beetle will be readily recognized by the following description: Beetles about one-fourth inch in length; head and antennae black; general body color yellow, with a black stripe on each wing-cover, and a third stripe where the wings meet along the back. Stripes run longitudinally.

These small beetles pass the winter under cover of leaves and trash around the garden. In the spring they come out and deposit eggs in the soil near the base of the food plants, and the larvæ when hatched live on the roots. These larvæ are slender little white grubs and when numerous they may do considerable damage. The principal injury is caused by the adults feeding on the leaves.

Remedies—Clean cultivation of the gardens after the crops are off in the fall so as not to leave any rubbish under which the adults may pass the winter. Protecting the young plants with gauze netting while the plants are small. Where plants are protected for three or four weeks, or until they get well started, the injury from cucumber beetles will not be great. Two pieces of wire bent over the plants in the form of a double arch, and thrust firmly into the ground, will make a good frame for a netting to cover young plants. Sprinkling plaster on the plants while young will often serve to keep the beetles away, but protection with netting is the only sure prevention.

COLORADO POTATO BEETLE.

(*Doryphora 10-lineata.*—Say.)

This troublesome pest of the potato plant is so common that it seems almost unnecessary to mention it. Still the fact of its being common seems to keep many people from learning how easily it may be controlled. It is a fact that our new insect pests

often receive more attention and are fought with more vigor than the ones that are always with us.

Fig. 14.—Adult Potato Beetle.*

Fig. 15.—False Potato Beetle.*

The Colorado potato beetle derived its name from its native home. Until about the middle of the nineteenth century this beetle was not conspicuous as a garden pest, for before that time it fed on weeds of the same genus as the potato plant.

Life History—Late in fall the beetles enter the ground and hibernate until the warm spring sunshine brings them out. The females soon commence to deposit eggs on the under side of the leaves. These eggs are yellow, occur in clusters and are easily seen. In a short time the eggs hatch into larvæ having enormous appetites, which they at once commence to satisfy. The soft-bodied larvæ increase in size with alarming rapidity and when full grown, which is in from three to four weeks, they go into the ground and form a smooth cell in which the pupal stage is passed. There are several broods in the South and larvæ of all sizes can generally be found on a plant. Fig. 14 shows an adult beetle.

Remedies—Paris green in any form is death to potato beetles. While the plants are small it may be applied as a dry powder mixed with ten times its weight of cheap flour, land plaster or air-slaked lime. This powder can be dusted on the plants while wet with dew early in the morning, or after sundown in the evening. The duster recommended for cotton caterpillar poisoning will be found useful. Or Paris green may be applied in liquid form, by mixing one pound of poison and two pounds stone lime in 125 gallons of water. The lime should always be used to prevent burning of foliage. It is even better to use the arsenical in connection with Bordeaux mixture.

DIRECTIONS FOR PREPARING BORDEAUX-PARIS GREEN MIXTURE.

Usually it is best to use Paris green or other arsenical poisons in connection with Bordeaux mixture, thus making one spraying serve two purposes.

* From original drawings by Mrs. W. M. Scott.

Bordeaux is used principally for controlling mildews and fungus diseases and in itself contains no insecticidal value, except as a repellant. Combined with arsenical poisons it serves to keep the latter from washing off so rapidly.

For convenience, the ingredients (copper sulphate, lime and water) of Bordeaux mixture, and their amounts, are designated by an abbreviated formula, the number of pounds of copper sulphate (bluestone) being written first, number of pounds of lime written second and number of gallons of water written last. Thus the formula "4-6-50," indicates a Bordeaux mixture of 4 pounds copper sulphate, and 6 pounds lime in 50 gallons water. The formula "3-9-50," would indicate 3 pounds copper sulphate, 9 pounds lime and 50 gallons of water, etc. Bordeaux mixture to be thoroughly effective must be prepared carefully. The following method of preparation will insure good results: Dissolve the bluestone in a barrel or tub, using a small amount of water. If hot water is used the bluestone will dissolve most readily, but the solution must be allowed to cool before mixing. Before immersing in the water tie up the bluestone loosely in a piece of burlap suspended from a cord. Place this in the water and keep moving. The bluestone will have all dissolved in a short time, when this solution should be diluted with clear water to 25 gallons. In another vessel slake the required amount of lime, using boiling hot water and adding water from time to time to prevent burning. When slaked dilute to 25 gallons. Dip up these solutions with buckets and pour them together into a third barrel, holding the buckets so that they are emptied simultaneously and not too fast. The streams should meet and mingle together in mid-air so that the solutions are thoroughly mixed before they reach the surface of the liquid in the barrel. When both solutions have been poured into the third barrel in this manner, stir up the mixture vigorously with a paddle and the Bordeaux mixture is ready for use. It is also now ready for the addition of Paris green or other poison. While spraying out the Bordeaux mixture only a pump with a good agitator should be used.

Green arsenoid is an article that may be substituted for Paris green. It is of a duller color, bulkier, more finely divided, and remains in suspension longer. It can be purchased for a little over half what Paris green costs and pound for pound it is worth about as much for poisoning insects. Growers are recommended to test this arsenical especially because so much impure Paris green is often placed on the market.

FLEA BEETLES.

Cucumbers, tomatoes, melons, turnips and many other garden vegetables are often attacked early in their life by little jumping beetles that make small round or irregular holes in the foliage, and from their ability to jump, they have been given the name of Flea Beetles. The damage from these little fellows is sometimes very severe as they attack the plants while small and tender. The larvæ are mostly leaf-miners, living in the tissue of the leaves and stems of the host plant, though seldom doing much damage.

Flea beetles vary in size and color, some of them being so small as hardly to be seen, while others, like the grape flea beetle, being nearly one-quarter of an inch long. All have thickened hind legs enabling them to jump readily. They will all be recognized

by this characteristic. Color ranges through steel blue, brown and black.

Remedies—Clean culture of the garden is the very best thing to practice, as flea beetles hide in rubbish and trash through the winter. When they appear in the spring young plants may be sprayed with arsenical poisons, unless the plants are protected by a cover as recommended for the Cucumber beetle. It has been found that young plants covered thickly with ordinary Bordeaux mixture are not often severely attacked, the mixture acting as a repellant. Usually it is best to add paris green or green arsenoid to the Bordeaux as it will poison some beetles. When the plants have attained some size they are seldom injured by these insects. Simply dusting plants with lime dust will drive some species of flea beetles away. However, it cannot be depended on in all cases and the best plan is to use an arsenical poison, or cover the plants.

CABBAGE WORMS.

(*Pontia rapae* and *Bontia protodice.*)

Every one living in the country has seen the common white butterflies that usually appear early in the spring and love to hover around in sunny places; but many perhaps do not know that these butterflies are the parents of our most common cabbage worms, that yearly depredate the cabbage patches. There are two common cabbage worms, one known as the imported cabbage worm, and the other as the native cabbage worm. The former was imported many years ago from Europe and the latter is indigenous to this country.

Imported Cabbage Worm (*Pontia rapae*)—The adult butterfly is white in color with a faint creamy tinge; the males have one black spot and the females two similar spots on each front wing. In addition to this they both have the front wings tipped with black. The hind wings in both sexes bear a black spot near the front margin. These butterflies have a wing expanse of from one and one-half to one and three-fourth inches. Worms when grown are green in color, sometimes having an obscure longitudinal black stripe along the back. The worms or larvæ when grown change to pupæ on the plant, attaching themselves by a silken band. There are several broods and the winter is passed in the pupal stage.

Native Cabbage Butterfly (*Pontia protodice*)—Adult males of this species closely resemble the imported species in size, color and marking. The females, however, look quite different; though white in general color the wings are much marked with angular black spots. The worms show four longitudinal pale yellow stripes, two on each side of the body. In other respects the species are much alike.

Remedies—Experiments show that cabbage worms succumb to any arsenical poison, but its use has not been generally recommended because of prejudice against the use of poison on account of danger of poisoning the consumer. It may be interesting to the reader to know that experiments have been made in which cabbage heads sprayèd with Paris green have been subjected to chemical analysis to find out how much poison actually remained after the first few days. In every case there was only a slight trace, if any; certainly not enough to be dangerous. Besides, cabbages grow from the inside out and the outer leaves are always removed before cooking. It may be said that with ordinary care it is safe to spray cabbages with arsenical poison. We do not, however, recommend its use on full grown cabbage.

Paris green or green arsenoid may be used with lime and water, in the following proportions: Paris green, 1 pound, stone lime, 1 pound, water, 150 gallons. Or arsenate of lead may be used at the rate of 2 pounds in 50 gallons of water.

Four sprayings through the season will usually suffice to keep the worms in check. When the plants are nearly full grown the use of *fresh* Hellebore powder is recommended. This should be dusted on the plants every two or three days. It soon loses its poison property when exposed to the air, hence the necessity of repeating the application so often.

PLANT LICE.

Several truck and garden crops are annually injured by small green, yellow or brown soft-bodied insects that live by sucking the plant juices. Plant lice are so small that they often pass unnoticed until considerable injury to plants has occurred, when the sickly appearance of the plants cause them to be examined. The lice usually occur on the under surface of leaves, when that is possible, though cabbages may be covered all over.

Melon Louse (*Aphis gossypii,* Glover)—These lice may appear on melons early in the spring, winged individuals coming from some of their many food plants in adjoining fields. The winged forms give birth to living young, and these in turn reach maturity in about eight days, and bring forth more young. The colonies thus formed live on the under side of the leaves and may soon cause small plants to turn yellow and die. The leaves soon become curled and mis-shapen. More colonies are established by winged individuals that fly from one place to another. These lice may continue to multiply all summer, unless checked by artificial means. The winter is passed in the egg stage, and possibly in hibernation.

Remedies—Spraying with kerosene emulsion or whale oil soap solution. To do this thoroughly the vines must be turned over or else use a curved rod to carry the spray to the under side of the leaves. Spray as soon as the first lice appear because when the leaves become curled the lice are hard to hit. Carbon bi-sulphide may be used to good advantage when the plants are small. Carbon bi-sulphide is a liquid and can be purchased from any drug store. Dr. John B. Smith* recommends using one dram, which is about equivalent to one teaspoonful to each cubic foot of space. A practically air-tight cover must be placed over each plant to be treated. The cover can be made of heavy ducking stretched over a light wood or wire frame. Place the liquid in a shallow dish on the ground and let the plant remain covered for one hour. It is estimated that five doses will cost only one cent if the carbon bi-sulphide is purchased at wholesale prices.

Cabbage Lice—For lice on cabbage we would recommend spraying with kerosene emulsion or soap solution. Oftentimes a strong soap solution made from common washing powder is found fully as effective as the kerosene emulsion. The thing to avoid is letting the lice multiply to great numbers before treating the infested plants. Furthermore, one spraying should not be expected to kill every insect, and as they increase with such rapidity, the second treatment should be given in four or five days after the first. Thoroughly controlling the lice while the plants are small is the best practice.

Plant lice on any crop may be controlled if taken in time. The

* New Jersey Exp. Sta. Bul. 121, p. 10.

insects are soft-bodied and easily succumb to any common contact poison.

In cabbage fields all stumps should be pulled out and burned to destroy the lice remaining after the crop is gathered. Also keep down such weeds as mustard, shepherd's purse and the like as cabbage lice flourish on such as well as on cabbage. Practice clean culture in gardens and along fence rows and walks near the garden.

Directions for Preparing Kerosene Emulsion.

Formula for stock solution:

Kerosene	2 gallons.
Hard soap (soft soap, 1 quart)	½ pound.
Water	1 gallon.

Place a kettle containing one gallon of water over a fire and in it dissolve the soap. The water should be boiling hot. Remove this solution from the fire and add 2 gallons of kerosene after which the mixture must be agitated violently for about ten minutes. As the kerosene and soap solution combine a smooth creamy emulsion will result, the bulk will increase nearly one-half, and when properly mixed the resulting emulsion will remain without separating for several weeks. This emulsion is most easily prepared by using a small force pump having a direct discharge and throwing a one-eighth inch stream, pumping the solution back into itself with considerable force. In six or eight minutes the emulsion, made in this way, will be perfect.

This stock solution of kerosene emulsion may be diluted with water to any required strength, but care should be taken to have it thoroughly mixed before using.

For convenient reference the proper amounts of water used in diluting the stock solution for certain strengths is given herewith:

For 5 per cent. emulsion dilute with 37 gallons of water.
For 10 per cent. emulsion dilute with 17 gallons of water.
For 15 per cent. emulsion dilute with 10⅓ gallons of water.
For 20 per cent. emulsion dilute with 7 gallons of water.

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GEORGIA STATE BOARD OF ENTOMOLOGY
Atlanta, Georgia.

GEORGIA
State Board of Entomology

BULLETIN No. 17.—OCTOBER 1905.

PEACH INSECTS

A Bulletin of Practical Information

BY

R. I. SMITH.

CAPITOL BUILDING Atlanta, Ga.

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Georgia State Board of Entomology.

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Field Assistant Entomologist, Atlanta.

To the Honorable Board of Entomology
of the State of Georgia:

I have the honor to submit the accompanying manuscript for publication and distribution in accordance with an Act of the General Assembly, approved December 20th, 1898.

This manuscript has been prepared to meet a growing demand among the peach growers of this State for information concerning all the principal insects attacking the peach. While the San Jose scale has been known for several years in Georgia, it has often become apparent that many fruit growers are familiar with its appearance, whereas it would seem that every fruit grower should be able to recognize this important scale insect wherever it occurs. Other scale insects somewhat closely related to the San Jose, should also be known, and the same thing is true of all other insects liable to attack the peach in Georgia.

It is thought that the descriptive part of this bulletin, supplemented by numerous illustrations, will enable the reader to know and recognize most of the important peach insects. It is hoped that this work will prove to be of interest, and of practical value to the peach growers of this State.

Very respectfully,

R. I. SMITH,
State Entomologist.

Approved:
T. G. HUDSON,
Chairman of the Board.

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BULLETIN

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SCALE INSECTS AFFECTING THE PEACH.

General Remarks: Among the numerous insects known to attack the peach in Georgia the several scale insects rank among those of most importance. Out of this class the San Jose scale stands at the head as being the best known and the most pernicious. Few there are who have not heard of this insect, though many persons as yet have not been compelled to fight this pest in their orchards. In Georgia, fortunately, there are still many localities entirely free from this dreaded insect and may with proper precautions remain so for a long time to come. Careful watch should, however, be kept for its first appearance. The San Jose scale cannot under present conditions be prevented from making yearly inroads on previously uninfested territory, and for that reason all who intend to engage in the fruit growing business should be able to recognize this insect at a glance. It is for the purpose of more thoroughly disseminating knowledge regarding the San Jose scale and its control, and for the purpose of calling attention to certain other scale insects liable to become injurious to the peach, that the first part of this bulletin has been prepared. Strange as it may seem many orchardists are still wholly unfamiliar with the appearance of the San Jose scale, its name only being familiar to them. About the other scale insects that will be mentioned comparatively little specific knowledge is possessed by the average orchardist.

The New Peach scale or West Indian peach scale, as it will be termed, stands next in importance to the one just mentioned. It will, however, be much more readily recognized on account of the white color of the male scales and the marked difference in appearance between the sexes, as described farther on. A very common scale insect in Georgia orchards is one that has been given

the name, Cherry scale, though it is more commonly found on peach than on cherry trees. It has often been mistaken for the San Jose scale, and owing to its somewhat close resemblance is not easily distinguishable, except by an expert. This scale while not considered seriously injurious in Georgia, is much more generally distributed than the San Jose scale. Putnam's scale insect is another closely related species and may be mistaken for the San Jose. It is not as prevalent in Georgia as the two forms just mentioned. The soft scale, peach Lecanium, is also frequently met with and deserves careful consideration.

Two other scale insects, namely, the Scurfy scale and the Oyster-shell Bark-louse, sometimes occur on peach trees, but as they are more commonly found on apple they will be reserved for discussion in a bulletin on apple insects to appear at some later date. For all practical purposes they need not be considered among peach insects. Following these general remarks six scale insects will be discussed separately, involving a description as well as remedy for each.

THE SAN JOSE SCALE.

(*Aspidiotus perniciosus* Comst.)

This is by far our most destructive scale insect, and one that every fruit grower should learn to recognize as it may attack pear, plum, apple, apricot, quince, persimmon, currant and other tree and bush fruits as well as the peach. It has been demonstrated without a doubt that this scale can be controlled in infested orchards, and it therefore behooves every fruit grower to learn to recognize this pest and be prepared to fight it from its first appearance. By doing so much damage and loss will be avoided.

Historical: The exact origin of the San Jose scale was for a long time in doubt though up to the year 1901 it was generally supposed to be a native of Japan or some Eastern country. During that year Prof. C. L. Marlatt made an extensive trip through Japan and after making a careful investigation, came to the conclusion that its native home must be elsewhere. His investigations extended into China and there in the Northern portion was found the native home of the San Jose scale.

In the United States the San Jose scale was first discovered at San Jose, Cal., in the early seventies and soon spread to several orchards in that vicinity. In 1880 the insect was studied and described by Prof. Comstock, then Entomologist of the United States

Department of Agriculture. It was he who gave this scale the name *perniciosus* as he declared it to be the most pernicious scale insect in the United States. Several years later—in 1893—this insect was discovered in an orchard at Charlottesville, Va. This discovery lead to an investigation revealing the fact that the San Jose scale had been imported into some Eastern nurseries, probably in New Jersey, five or six years previous to 1893, and from those nurseries it had been widely distributed over the eastern fruit growing states. When discovered at Charlottesville many other points of infestation occurred and it soon became apparent that extermination would be impossible. Hence every effort was directed toward finding a method of killing the scale in the infested orchards. These efforts have been crowned with success, so that now in Georgia, as well as elsewhere, scale infested orchards are sprayed each year with every assurance of success.

Description: The San Jose scale is so small that any description must be largely general in its nature. The full grown individuals are only about 1-16 inch in diameter, hardly the size of a small pin-head. Its characteristic shape and coloring can only be detected accurately by the use of a good hand lens, and when examined closely much variation will be noticeable between individuals.

Fig. 1.—Twig with San Jose scale of all ages; magnified five times. (After Alwood, Vir. Crop. Pest Comm., Spec. Bull., No. 45.)

A full grown female San Jose scale is ashy-gray in color, almost round in outline, and in the center of the upper surface of the scale there is a small dark colored ring surrounding the nipple. This nipple is characteristic of all scale insects belonging to this

same family, its location and color often being a help in determining the exact species. The nipple is formed in part by the first molt or cast skin of the young insect while the subsequent scale formation is due largely to secretions from the body of the insect, these secretions gradually hardening when exposed to the air. Close examination will reveal two or more quite distinct rings around the nipple. These rings are developed when the insect undergoes its second, third or fourth molt. The resulting scale is slightly conical, sloping evenly in all directions. The above is a description of the outward appearance of a full grown female scale formed under perfect conditions. When crowded on a branch they often assume widely differing shapes.

This mature scale as described above conceals the body of the true insect underneath. By using a pin or knife point the hard scale may be lifted revealing the orange-yellow body of the female insect. (Fig. 2.)

Fig. 2.—Old San Jose scale with true insect exposed, to right. (After Alwood, Vir. Crop Pest Comm., Spec. Bull., No. 45.)

The male San Jose scale differs from the female by having an elongated growth to one side. In size the males are smaller and often darker in color and the central nipple and first ring will be noticed at the anterior end of the elongated scale. Fig. 1 represents the comparative size and shape of the male and female scales as they appear on an infested twig.

Life History: Speaking specifically of the life history of the San Jose scale, the females, when from 33 to 40 days old, begin to give birth to living young. Eggs are never deposited by this species. The young scale insects are almost microscopical in size, having oval shaped bodies of a bright orange yellow color. Soon after birth they commence moving about looking for a place to settle and commence feeding. Often from 12 to 24 hours are consumed before they settle down and insert the minute beak with which the juices of the plant are sucked up for the nourishment of the young insect. After these young scale insects once settle and commence feeding their position

is never changed, except in the case of the male which changes to a winged form. At the end of twelve days, according to Dr. L. O. Howard,* the first molt occurs, going to make up the nipple of the subsequent scale as already described. Up to this period the two sexes are exactly alike. When this first molt occurs the insect under the scale changes in appearance, the legs disappear, and the little insects look like yellow flattened balls. At from 18 to 20 days the second molt takes place, and from then on the males and females differ widely in appearance. The males begin the development of the elongated scale covering while the true insect underneath changes to a pupa from which there emerges at the expiration of 24 to 26 days the adult winged male as shown in the illustration. (Fig. 3.) The female insects take longer to become fully mature. Dr. Howard places the time at thirty days. At this age the body of the female contains quite well developed embryonic young which begin to make their appearance from the 33rd to the 40th day. These minute young insects seek a feeding place as already described.

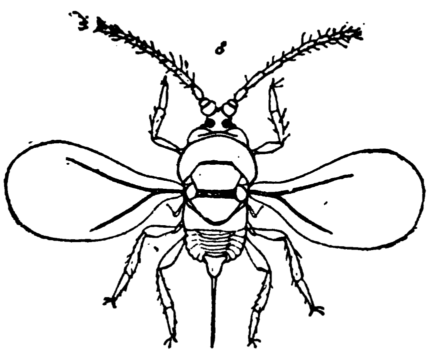

Fig. 3.—San Jose scale, adult male—greatly enlarged. (After Howard, Yearbook, 1894, U. S. Dept. of Agr.)

Examination of a scale infested tree during summer will show insects of all sizes from newly born larvae to full developed males and females. Each adult female may give birth to from 300 to 400 young, covering a period of possibly two weeks; hence the first born may be past the first molt when the later ones appear. In Georgia there are at least five generations each season.

It should have been stated that the males and females are nearly jet black except for the central nipple, until about one-half grown, the ashy-gray color appearing later. These perfectly round nearly black scales, having a prominent nipple surrounded by a slightly grayish ring are very characteristic and easily distinguished from nearly all other scale insects.

HOW THE INSECT PASSES THE WINTER AND HOW TO DETECT IT.

The winter stage is passed by the San Jose scale as half grown or nearly mature individuals. Most of the mature females perish

*U. S. Dept. of Agr., Bureau of Ent., n. s. Bull. No. 3.

from cold and exposure to the weather. During winter a badly infested tree will present a gray appearance described by some as looking as though coated with wet ashes. The old dead scales may be packed closely together and piled on top of one another. This color will be relieved in places by the black, circular, half grown scales as described above. The greater number of young scales will be found on the less thickly coated portion of the infested limbs and around the base of young shoots and branches. By drawing a knife blade or thumb nail along an infested branch an oily yellowish fluid will exude caused by crushing the soft-bodied insects under the scales. Another characteristic feature of the San Jose scale is that it causes the bark to turn red at the point of attack. This is especially noticeable on the young wood of the peach. The bark turns red nearly or quite to the wood as determined by shaving off a thin section. Isolated scales may cause a red blotch, in diameter, several times the size of the scale itself. The bark of infested peach trees often shows a marked depressed or pitted appearance, explained by the fact that the bark nearly ceases growth at the exact point of attack, while the surrounding tissue continues to increase in volume. Peach trees badly infested with scale often commence to die the second year, though sometimes when infested at the age of two or three years they will survive for several years afterward. Wherever orchards are watched closely this dying may be prevented by proper remedial treatment as described in the next paragraph.

REMEDIES.

During the many years that remedies have been tested against the San Jose scale almost everything having any insecticidal value has been tested. The whale oil soap treatment has been given a thorough test in Georgia and other states, and, while giving more or less satisfaction, it has proved to be too expensive for general use. Kerosene and crude petroleum in mechanical mixture and as emulsions were used in Georgia quite extensively during the early fight against the San Jose scale. Both were tested thoroughly by Prof. W. M. Scott, first Entomologist for Georgia, and his results were published in bulletins during 1901-02. He found that the use of either kerosene or petroleum was attended with some danger of killing the sprayed trees—largely on account

of careless labor—hence their application has been practically abandoned except in the case of kerosene which is still recommended for summer treatment as mentioned farther on. Caustic soda has been carefully tested and reported on in Bulletin No. 14—still available—as well as many patent scale washes calculated to kill scale but proving to be of very little value.

Results obtained from the use of Lime-Sulphur-Salt washes, tested first in Georgia during the winter of 1901-02, and further tested in the springs of 1904 and 1905, have demonstrated without any doubt that in them a safe and reliable remedy for the scale has been found.

Winter Treatment: For winter treatment of scale infested trees the following wash is recommended to be used as a spray, applying it with a spray pump to every tree in infested orchards. This recommendation is based on the result of experiments that have been conducted by the Georgia State Board of Entomology, and on the experience of large orchardists who have tested this wash on thousands of trees with most excellent results.

Lime-Sulphur-Salt Wash.

Formula:	Lime ----------------	20 pounds.
	Sulphur ---------------	16 pounds.
	Salt ------------------	5 pounds.
	Water, to make---------	50 gals.

Mix the sulphur into a thin paste with a small amount of water and then add it to about 15 gallons of boiling water in a kettle (or in the boiling tank if steam is used) and stir thoroughly. While this mixture is at the boiling point add the stone lime, which will immediately commence to slake, causing violent ebullition. While the lime is slaking much of the sulphur will be dissolved, as will be evident from the rich amber color resulting. The lime should be stirred frequently while slaking and water added as necessary to prevent burning or too violent boiling. After the lime is through slaking add the salt and continue the boiling for at least 35 minutes or longer if it seems necessary to dissolve all the sulphur.

This wash when properly prepared should be a dirty yellowish-green color when agitated, but if allowed to settle a clear amber-

Fig 4.—A complete plant for boiling lime-sulphur wash; built by John T. West, Thomson, Ga.: Large water tank in rear above; boiler house to left—not shown in picture; platform supporting 50 gallon barrels fitted with steam connections; 250 gallon spray tank and spraying gang, on right. (Photo. by author.)

colored liquid will appear on the surface. There is always a residue which settles quite readily, necessitating frequent stirring, or better, constant agitation while in the spray tank. A wash of this kind should be strained through a wire screen or heavy burlap to remove all large particles of lime or other foreign matter that would tend to clog the spray pump. It is essential to have a large per cent. of what may be termed the residue, forced through the pump and onto the trees as it plays an important part toward killing the scale.

Lime-Sulphur Wash.

Formula:	Lime ----------------	20 pounds.
	Sulphur --------------	16 pounds.
	Water, to make--------	50 gals.

This wash is made in the same way as the one just mentioned, simply leaving out the salt. The lime and sulphur wash has proved in our experiments practically as effective as the wash including salt. Many fruit growers in Georgia are at present using this formula, and assert that the salt is of no benefit. Some reliable authorities, however, still insist that the salt is essential so it is deemed best at this time to offer both formulas and let individual preference decide which to use. Either one has proved thoroughly effective during the past two seasons.

The lime-sulphur washes as recommended are intended primarily for winter spraying work while the trees are perfectly dormant. They cannot safely be used after the trees bud out in spring or at any time during summer. Badly infested trees should be sprayed twice during winter and when this is done, once in December and again in January or February, San Jose scale may be practically exterminated. Trees only lightly infested are usually sufficiently protected by one thorough spraying during January or February of each year.

Summer Treatment: Orchards properly treated during winter will seldom require summer spraying so far as the San Jose scale is concerned. Sometimes, however, a new infestation may be discovered in late spring or summer and in order to prevent the scale from multiplying so rapidly through the summer months, the trunk and main limbs of the infested trees may be treated with

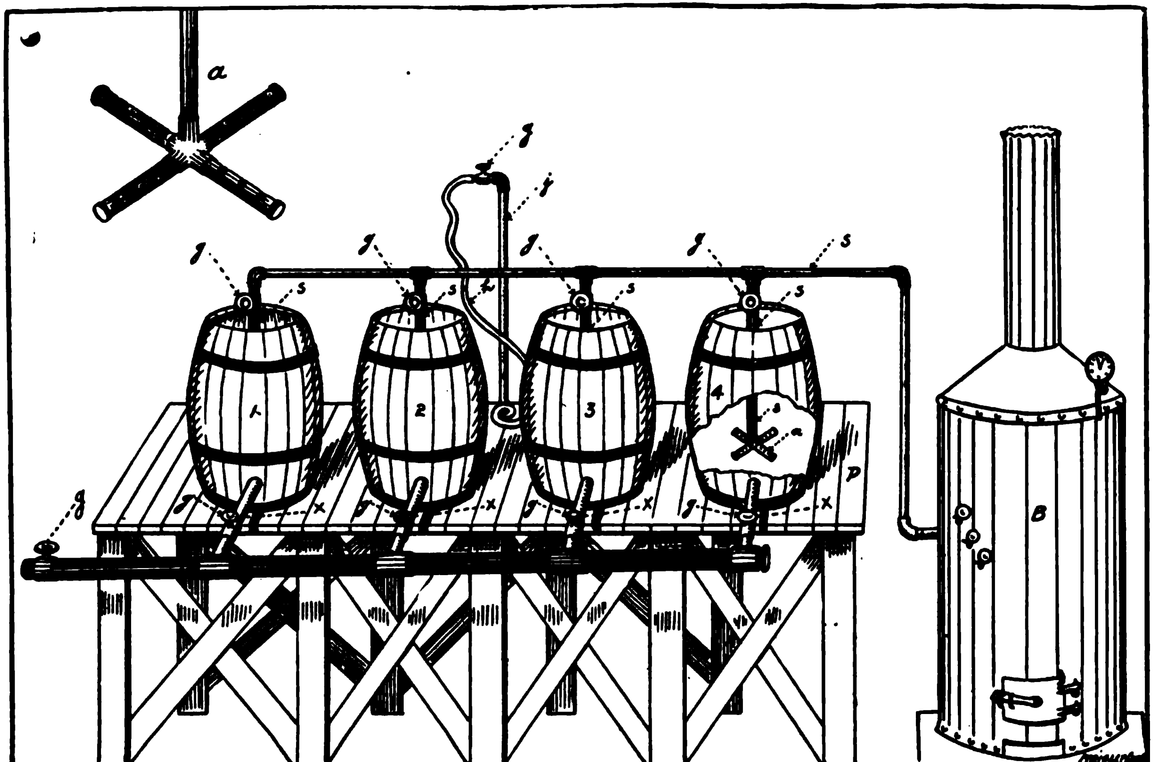

Fig. 5.—A simple steam boiling outfit for preparing lime-sulphur washes: B, boiler; ss, steam pipes; gg, globe valves; 1, 2, 3 and 4, 50-gallon barrels; xx, pipes for drawing off mixture after boiling; F, large pipe carrying liquid from pipes xx to wagon tank or spray-barrel; a, lower end of steam pipe with cross-arms and one-eighth inch openings for escape of steam; P, platform 6 feet above ground; f, pipe supplying water from elevated tank or steam jet; h, water hose for carrying clear water to 1, 2, 3, and 4.

the lime-sulphur wash prepared as for winter spraying. It can be applied with a mop or large brush or a spray pump may be used if care is observed to prevent the spray from being thrown on the foliage. A wash of the strength recommended will burn peach foliage severely and often kill back young tender shoots.

KEROSENE EMULSION AS SUMMER TREATMENT.

In 1902 the writer conducted experiments with kerosene emulsion on peach trees, in Maryland, during the month of July. In 1904 further tests were made by the writer in an orchard at Myrtle, Ga., and again in 1905 at Mayfield and Thomson, Ga. At Mayfield the test was made on trees not infested with the San Jose scale, but at all the other places badly infested trees were sprayed. Injury to the treated trees could not be detected in any of these experiments. The first spraying in 1905 with kerosene emulsion was made May 24th and 25th, and the last spraying August 10th. In no case could damage to the trees be detected, except a slight burning of foliage. In view of the results obtained by the various experiments it is deemed safe to recommend the use of kerosene emulsion as a summer treatment for San Jose scale; *provided, however, that the work be done strictly according to direction with emulsion properly made, so that the kerosene will not separate in the spray tank.*

Kerosene Emulsion.

Stock solution:	Kerosene	8 gallons
	Hard Soap	2 pounds
	Or Whale Oil Soap	4 pounds
	Water	4 gallons

Place 4 gallons of water in a 15 or 20 gallon kettle, bring this to a boil and in it dissolve the soap. Remove this soap solution—*while boiling hot*—from the fire and add 8 gallons of kerosene after which the mixture must be violently agitated for about ten minutes. As the kerosene and soap solution combine a smooth, creamy emulsion will result, the bulk will increase somewhat, and when properly prepared the resulting emulsion will remain without separating for several weeks. This emulsion is most readily made by using a small force pump having a direct discharge and

throwing a one-eighth inch stream, pumping the solution back into itself with considerable force. After ten minutes pumping the emulsion will be perfect. Soft water should be used for making emulsions, but if such water is not readily obtainable, hard water may be broken by the addition of a little lye and can then be used with safety. Persons making emulsions for the first time should be sure to agitate the mixture as directed, otherwise while it may look thoroughly mixed it may soon separate when allowed to stand.

The stock solution may be diluted to any required strength. For summer treatment I would recommend using an emulsion containing 20 per cent. of kerosene. In the experiments briefly mentioned above, 25 per cent. emulsion was employed without injury to the trees, but the 20 per cent. strength was almost equally effective; 20 per cent. emulsion kills nearly all the scale when applied during the summer months; 15 per cent. emulsion has often been recommended but it does not always give satisfactory results. It is not advisable to spray trees with nearly ripe fruit, as the fruit absorbs the kerosene and may taste so strong when ripe, as to render it unsalable and unfit for home use.

Note: **For a more complete discussion of how to spray and what equipment is required, and how to prepare lime-sulphur wash, particularly by the steam boiling process, the reader is asked to send for Bulletin No. 14 of the Georgia State Board of Entomology. Application should be made to the State Entomologist, Atlanta, Ga.**

PUTNAM'S SCALE INSECT.

(*Aspidiotus ancylus* Putn.)

Of the scale insects occurring in Georgia this is perhaps the species most closely resembling the San Jose. Fortunately this scale is by no means as destructive and not at present one to be seriously feared. It is well, however, to know what scale insects may occur in the peach orchards, as by watching constantly for all species the more destructive forms will be discovered. In New York state Dr. E. P. Felt records this scale as being the most common species of *Aspidiotus* on fruit trees and shrubs in that state. In Massachusetts it has been reported as being particularly destructive in an apple orchard. In Virginia this scale is quite commonly mistaken for the San Jose.

Description and Life History: Putnam's scale insect is in many

respects similar to the San Jose scale and hence a comparative description only will be given.

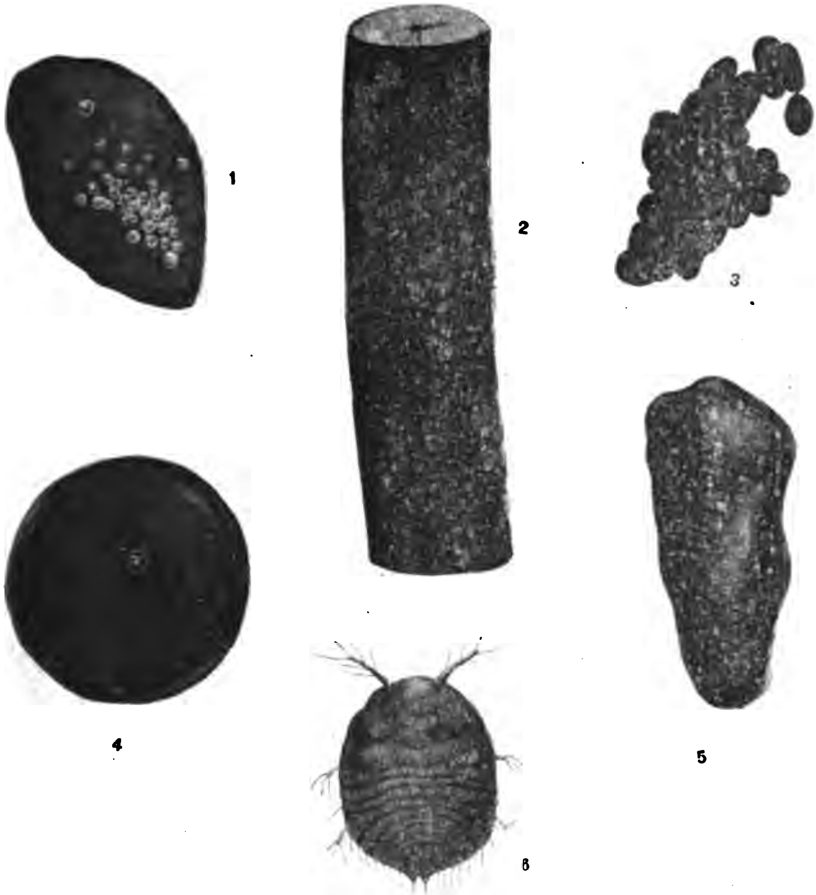

Fig. 6.—Putnam's scale insect: 1, group of young scales, enlarged; 2, badly infested twig, enlarged; 3, portion of 2, greatly enlarged; 4, female scale, greatly enlarged; 5, male scale, much enlarged; 6, young scale insect, very greatly enlarged. (After E. P. Felt, N. Y. State Bull., No. 46.)

The adult female scale shown in Fig. 6 is slightly larger than the San Jose, being about 1-12 inch in diameter. In color they are dark gray, and the nipple is reddish colored and slightly to one side of the center. The male scales are dark gray with the reddish nipple showing prominently. Their elongated shape is well shown in the illustration. Like the San Jose scale this species passes the winter as partly grown individuals, but according to

Dr. E. P. Felt,* they are usually more nearly mature than the over-wintering San Jose scales. In spring the males and females complete their growth, the former emerging as small winged individuals and the latter depositing eggs under the protecting scale. Dr. Felt states that only one brood develops in New York, but in this State there are probably at least two. The rate of reproduction of the Putnam's scale is slow compared to the San Jose scale, which is fortunate, as otherwise it might be a very destructive insect.

REMEDIES.

The over-wintering, partly grown scales may be killed by an application of the lime-sulphur wash as recommended for the San Jose scale. If the infested trees are sprayed during winter no summer treatment will ordinarily be necessary. But if numbers of young crawling insects are observed during summer they may be destroyed by the kerosene emulsion treatment as recommended on page 69.

CHERRY SCALE.

(*Aspidiotus forbesi* Johnson.)

Historical: This scale insect was first described by Prof. W. G. Johnson in 1896, it having been discovered by him in Illinois in 1894. It frequently occurs on wild cherry and was for that reason given the name, Cherry scale. Prof. Johnson, writing in 1896,† stated that it was not an uncommon thing to find 7 or 8 year old cherry trees in Illinois literally covered with this destructive scale insect. At the same time he stated that many parasites were known to attack this species, and this fact may explain why the cherry scale is no more destructive in Georgia at present.

In Georgia the cherry scale is found in greater or less numbers in nearly every old peach orchard in the state, but in connection with this wide distribution it should be stated that the cherry scale has not been, and cannot be considered at present, as a particularly destructive scale insect. In the majority of orchards where it has been discovered in Georgia, parasites have appar-

*Bull. N. Y. State Museum, No. 46.
†U. S. Dept. of Agr., Bur. of Ent., Bull. No. 6, p. 75.

ently succeeded in holding it in check sufficiently to avoid the necessity of spraying as must always be done to control the San Jose scale.

Description and Habits: The Cherry scale, like Putnam's scale insect, is closely allied to the San Jose, and to the novice it is not easily distinguishable. The full grown female scale, as well

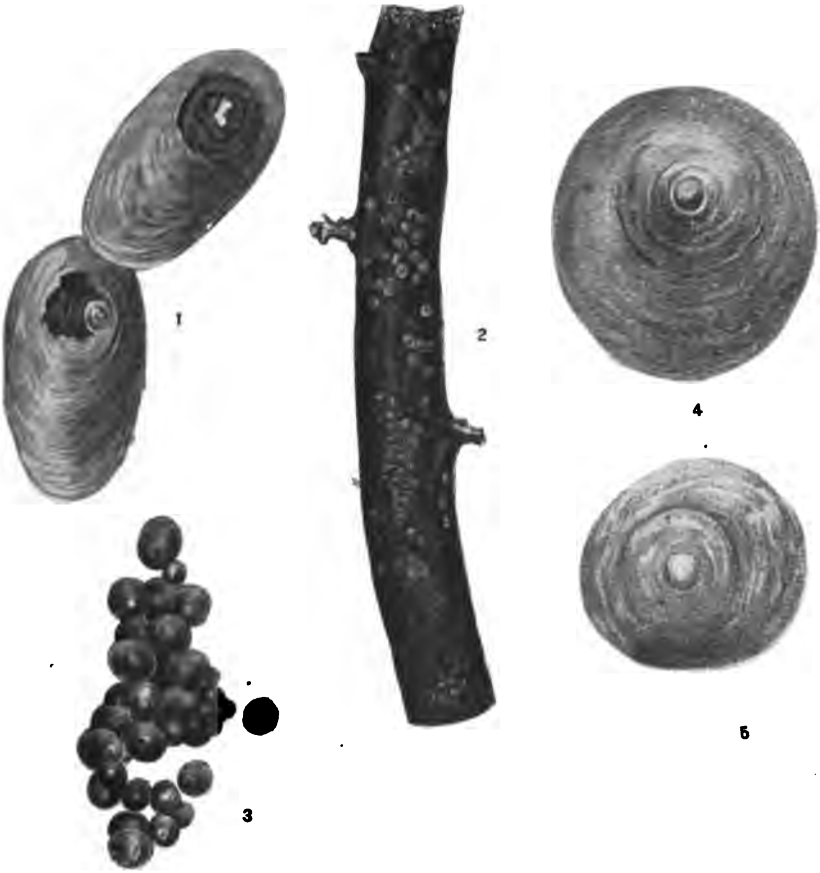

Fig. 7.—Cherry scale: 1, two male scales, very much enlarged; 2, twig infested with grown scales, natural size; 3, portion of 2, enlarged; 4, full grown female, much enlarged; 5, half grown scale, greatly enlarged. (After E. P. Felt, N. Y. State Bull. No. 46.)

shown in the illustration, (Fig. 7) is nearly round; natural color yellowish gray; scales rather flat and about 1-12 inch in diameter. Near the center of the scale but always somewhat to one side, is the reddish nipple or exuvia. The male scales are elongated.

smaller than the females, and the nipple at the anterior end is bright orange red. This bright color is especially prominent when the scales have been handled, rubbing off the thin outer surface covering.

The characteristic features distinguishing this species from the San Jose scale, are mainly, that the former are flatter, the nipple always to one side and orange red in color,—as compared to the central yellowish gray nipple of the San Jose—and a twig infested with cherry scale alone does not show the small circular black scales like those of the young San Jose. With this description in mind one would hardly confuse the cherry and San Jose scale. The Cherry scale hibernates as partially grown individuals, completing their growth in early spring, and unlike the San Jose scale, the females deposit eggs from which little lice hatch, similar in appearance to the young of the San Jose. Just the date when the first young appear in Georgia from the eggs of the first brood, is not definitely established, and is not necessary for the purpose of this bulletin. There are probably as many as three generations each season in this State. On scale infested trees young crawling lice may be found during almost all of the summer months.

REMEDIES.

The remedies recommended for the San Jose scale are equally effective against the cherry scale. While spraying is not generally practiced against this insect the writer has observed orchards where spraying would be advisable. The winter spraying should suffice if thoroughly done and in that event summer treatment will not become necessary.

WEST INDIAN PEACH SCALE.

(*Aulacaspis pentagona* Targ.)

This scale insect deserves more than passing attention as it is capable of doing great damage, its importance in Georgia being second only to the San Jose scale.

Historical: The West Indian Peach scale is known to occur in many countries among which may be mentioned England, Italy, Australia, Japan, China, South Africa, Panama and the West Indies. It is supposed that the native home of this insect was either Japan or the West Indies, and from the latter place it

has derived the common name, West Indian Peach scale. In the United States this scale is known to exist in Massachusetts, Washington, D. C., Ohio, Florida, Alabama and California, as well as in Georgia. In 1899 Prof. W. M. Scott recorded its occurrence at Thomasville, Bainbridge, Irby and Ashburn, Ga.,* and reported that about 10,000 trees were utterly destroyed at Irby. The cold winter followed by the February freeze in 1899, froze out nearly all the scale in the South Georgia orchards, and for awhile it was not present in destructive numbers. Since then, however, it has gained some headway and considerable spraying has been required to keep it in check. With our present knowledge of the destructive powers of this insect it is well to keep a sharp lookout for fear it may increase to its former destructive numbers, and also spread to new feeding ground. Since the writer has been with the Department no new cases of infestation by this insect have been discovered or reported. We have reason to hope that this scale will not be allowed to spread further, and it is to help prevent the possibility of such an occurrence that this discussion and description has been prepared. All fruit growers should be prepared to recognize this scale at a glance. By exterminating any newly discovered infestation, the possibility of a recurrence of the calamity at Irby will be reduced to a minimum.

Description and Life History: A glance at Fig. 8 will show

Fig. 8.—West Indian Peach Scale: a, branch covered with male and female scales—natural size; b, female scale; c, male scale; d, group of male scales—enlarged. (After Howard, Yearbook, 1894, U. S. Dept. of Agr.)

*Ga. State Board of Ent., Bull No. 1.

the reader that this is an insect quite different in appearance from the preceding forms mentioned above, the chief differences noticeable being the wide variation between the male and female scales, and the shape and color of the former. The adult female scales are gray and not readily noticeable. The nipple is always to one side of the center and characterized by being ridged and comparatively large. These females usually cluster on the trunks of infested trees. The males are most prominent, being white in color, elongate, parallel sided, and having the exuvia or nipple situated at the anterior end. They prefer to cluster near the base of large limbs and when abundant, give the tree a white-washed appearance.

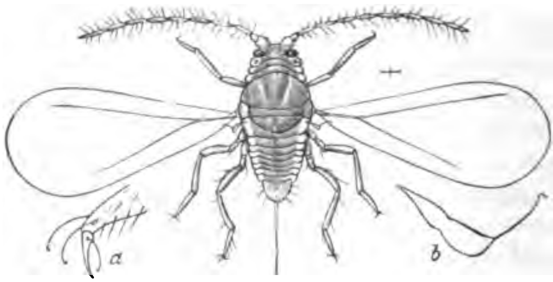

Fig. 9.—West Indian Peach scale: Adult male—greatly enlarged. (After Howard, Yearbook, 1894, U. S. Dept. of Agr.)

Concerning the life history Dr. L. O. Howard writes as follows:* "During the winter this insect is found in Washington, D. C., only in the condition of the mature female. The eggs are developed early in May, and the young larvae hatch by the middle of the month. The males (See Fig. 9) begin to issue the middle of June and impregnate the females, and the latter begin egg laying by the end of the month. The second generation is full grown by the middle of August, and the third egg laying begins at this time. In this latitude the development is comparatively regular." In Georgia no definite observations have been made to confirm this account, but very possibly a fourth generation may occur in this latitude thereby increasing the rate of multiplication. Everything considered this insect is much to be feared and should be looked for and immediate steps taken to exterminate it when discovered.

*Yearbook, Dept. of Agr., 1894, p. 267.

REMEDIES.

Winter spraying with the lime-sulphur wash will be found effective, and this is probably the best remedy, though summer treatment with kerosene emulsion or whale oil soap solution, just after the young have hatched, may at times become necessary. Whenever a fruit grower discovers any infested trees they should be immediately dug up and burned, while the surrounding trees should be given a thorough winter spraying.

PEACH LECANIUM.

(*Eulecanium persicae* Fab.)

This scale insect, quite unlike the forms just mentioned, is a native European species. It has become established in some Georgia orchards and in certain instances quite severe infestations have been reported.

Description and Life History: Unlike the San Jose scale and closely allied species this scale insect does not develop a specific hard scaly covering. The lecaniums are known as naked scale insects, often called "soft scales." "Turtle-back scale" is also a common appellation and one quite suggestive of the appearance of the peach lecanium and other closely allied species. The insect itself forms the scale and when examined closely it will be observed that the outer body wall is hardened but not separate from the insect within.

The nearly mature female lecanium (Fig. 10) is hemispherical,

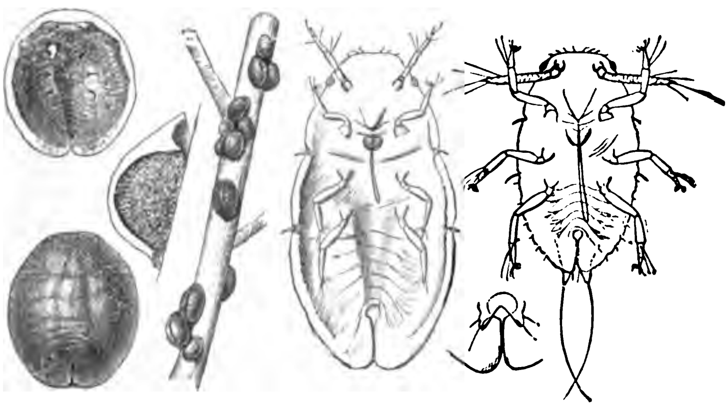

Fig. 10.—Peach Lecanium: Newly hatched larva on right; unimpregnated female next; full grown females on twig—natural size. (After Howard, Yearbook, 1894, U. S. Dept. of Agr.)

somewhat elongated, brown in color and quite hard in texture. The nearly grown scales may be found clustered on small twigs and branches during winter when they are readily seen. When spring arrives these insects commence to grow and soon the females deposit eggs. The male scales change to a winged insect, but on account of being so small and living only a short time, the adult males are seldom observed. The eggs may be found in the hard scale, which when crushed appears to contain only a powdery substance. The female insect shrivels up in the shell and practically disappears when the eggs are developed. From these eggs young lice appear, probably for the most part during June in this State. A young lecanium larva is shown in the figure.

When the insects are abundant on peach twigs a perceptible amount of honey-dew is frequently secreted. This sweet substance gives rise to a smut fungus which often covers the bodies of the scales, destroying many of them.

REMEDIES.

It has usually been considered that the best time to destroy the peach lecanium and other lecaniums is just after all the eggs are hatched in early summer. This may be done provided the orchardist will observe the date of hatching and prepare to spray the trees soon thereafter. The unprotected young will succumb to a treatment of 15 per cent. kerosene emulsion or to whale oil soap, one-half pound to one gallon water. Generally speaking such spraying should be done in Georgia about the middle of June. Such work will seldom be necessary, however, wherever orchards are sprayed thoroughly with lime-sulphur wash during winter. The writer has seen one case, however, where a tree infested with peach lecanium and San Jose scale, was sprayed with this wash during February and the lecaniums were apparently unharmed. This must be an exceptional case, however, and was partly explained by the fact that the lime-sulphur wash used was not full strength, owing to lateness of the season, and fear of injuring fruit buds.

Plum Pulvinaria.

(*Pulvinaria amygdali* Ckll.)

The Plum Pulvinaria belongs to the class of scale insects known as "soft scales". While somewhat closely related to the *Lecanium*

scale, just mentioned, it differs much in appearance from the lecaniums proper.

Occurrence in Georgia: This scale was found and reported during 1904 from Marshallville, Macon and Albany, Ga. At Marshallville the infestation involved a plum orchard of several hundred trees, and at Macon it was found on several plants including wild haw and plum. This may well be considered among peach insects as it frequently lives on the peach trees.

Description and Habits: The winter is passed by the half-

Fig. 11.—Plum Pulvinaria: On foliage as found during summer. (From Photo.)

grown female scales on the branches and twigs of infested trees. In the winter stage they are not particularly conspicuous. In spring these over-wintering insects commence to grow and develop the white cottony growth which constitutes the egg sac, and is a very conspicuous object. As the females near maturity a close examination of an individual would reveal a small brown, hardish bodied insect at one end of the cottony sac. In the sac would be found numerous minute eggs. These eggs hatch in early summer and the young crawl out on the foliage and there develop into the adult form as described above. (Fig. 11.) We do not know about the number of broods each year. Before the foliage falls the partly grown females have fastened themselves to the limbs and branches, there to pass the winter.

REMEDIES.

The winter spraying measures advocated for San Jose scale are effective against this pest also.

BORING INSECTS ATTACKING THE PEACH.

General Remarks: Peach trees in Georgia are attacked annually by boring insects causing considerable damage, much of which could generally be avoided were these insects more familiar to the fruit growers. The common peach tree borer, which works at the base of the trees, is known by nearly all fruit growers, but many do not know the life history of the insect and therefore do not know how to fight it intelligently. The following description, with remedial suggestions, is intended to be of value by causing greater familiarity with this insect. The fruit-tree bark-beetle should also be made the object of study and watched for each year, and also the peach-twig borer with which many fruit growers are familiar. In general it may be said that the peach-tree borer is one of the worst enemies of the peach in Georgia, though the other boring insects mentioned herewith cause considerable damage in certain years.

THE PEACH-TREE BORER.

(*Sanninoidea exitiosa* Say.)

Nearly one hundred years ago the peach-tree borer was described, and since that time it has been more or less familiar to fruit growers in the Eastern and Middle States. Before the introduction of the peach into the United States this insect probably lived in wild cherry or plum. It has been determined that the peach-tree borer is a native of the Eastern States and has followed the peach wherever it has been planted in the Middle and Western States, until now peach growers in all parts of our country east of the Rocky Mountains are generally familiar with the work of this important peach tree pest.

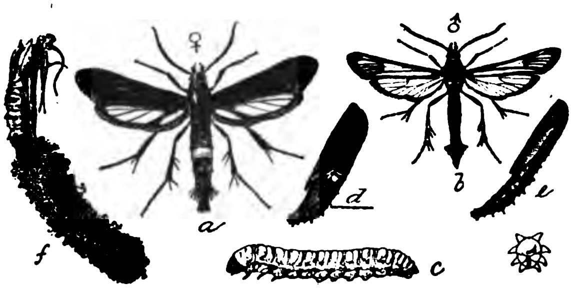

Fig. 12.—Peach-tree Borer: a, adult female; b, adult male; c, full grown larva; d, female pupa; e, male pupa; f, pupal skin partially extruded from cocoon—all natural size. (After Marlatt, U. S. Dept. of Agr., Bur. of Ent., Circ. 54.)

General Description: The gummy exudations about the base of peach trees caused by the larvae of the peach-tree borer, is a well-known sight to every fruit grower. All stone fruits, such as peach, plum and cherry throw out this copious mass of gum when injured in any way, and the peach more particularly. Exudations of a brownish gummy mass, more or less mixed with borings, earth and larval excrement, when occurring at the base of peach or plum trees, indicate the presence of borers underneath. These masses of gum often extend entirely around the base of badly infested trees, but being close to, or beneath the surface of the soil, they may be over-looked for some time unless the earth is scraped away from the trees.

The adult peach-tree borers resemble wasps in size and shape, being sometimes mistaken for them. The sexes differ so much in appearance that one would hardly take them to be the same

species. The adult moths are shown in Fig. 12, a and b, where the difference in size can be noted. The female moths have the fore wings blue, covered with scales, while the hind wings are transparent, resembling those of the males. Both sexes are steel-blue in general body color, but the abdomen of the female is marked with a broad orange band which is absent on the body of the male.

The adult moths appear mainly during the last part of August and the first half of September, as stated farther on, and the females soon commence to deposit eggs. From these eggs minute worms hatch and soon begin to bore into the bark near the ground causing an exudation of gum as mentioned above. When full grown the worms or borers are about one inch in length, yellowish white in color with the head and first body segment brown. (Fig. 12, c.) When full grown the larvae leave their channels in the trees and construct a cocoon at the surface of the ground, near the base of the tree from which they emerged, and change to a chrysalis, or pupa, in the cocoon. From the cocoon the adult moths issue, escaping from the pupal skin which is usually left attached to the cocoon as shown at Fig. 12, f.

The above is a very general description of the peach-tree borer and its work. A more specific discussion of the life history follows, as it has a direct bearing on the method of treatment and should be well understood.

Life History: Starting with partially grown larvae (borers) as found during winter in infested peach trees, we will follow out the entire life history of the peach-tree borer. The writer is indebted to Prof. H. N. Starnes of the Georgia Experiment Station, for the facts pertaining to the life history of this insect, and the following statements are taken—with his generous consent—from his paper before the Georgia State Horticultural Society.* Prof. Starnes' observations show that the larvae are about one-half or two-thirds grown at the approach of spring, having fed until late in fall and probably remained in a hibernating state during a portion of the winter. During the spring and early summer the larvae complete their growth, and it is during this feeding period that a great part of the injury is inflicted on the infested trees. When full grown the larvae leave their channels in the wood and proceed to construct cocoons near the surface of the ground at

*Proc. 29th Annual Meeting, Ga. State Hort. Soc., 1905.

the base of the trees. These cocoons are dirty brown in color, depending somewhat on the color of the soil. They are about one inch in length. (Fig. 12, f.)

By far the largest number of larvae leave their channels during the latter part of July and the first part of August, though some individuals come out earlier and some later. Immediately after constructing their cocoons the larvae pupate, changing to the pupa or chrysalis, which is a shiny brown object of the shape illustrated at d and e in Fig. 12. The pupa stage lasts from three to four weeks when the change to the adult takes place, and there emerges the adult moth as already described. The cocoons with the pupal skin extruded (Fig. 12, f.) are easily found about the base of infested trees.

Considering that the great majority of larvae spin cocoons and pupate during the month of August and that the adult moths emerge in at least four weeks thereafter, it is evident that most of the adult moths will be found during September. Prof. Starnes states that the majority of moths—in the latitude of Griffin. Ga.—emerge between August 26th and September 15th. Soon after emergence mating takes place and oviposition soon follows.

The eggs are very small, oval and light brown in color. They are deposited by the females on the trunk, mainly close to the level of the ground, but at times high up on the trunk and even on the lateral limbs. Quoting Prof. Starnes: "The eggs are practically all hatched by October 15th, and the young larvae, which are at first very minute, drop to the surface of the ground and begin to channel into the interior of the tree, where they remain throughout the winter, dormant a small part of the time, but feeding vigorously throughout fall and spring and well into the summer."

This point about the egg-laying and hatching, and the manner in which the young larvae bore into the trees is of great importance, as on it hinges the best methods of treatment.

REMEDIAL MEASURES.

Now that we are familiar with the true life history of the peach-tree borer it is evident that some of the time-honored recommendations for preventing the borer must be modified or changed somewhat. The life history, as stated above, is based on work done near Griffin, Ga., and there is a probability that the exact dates given may vary in different parts of the State. However, this variation will not be sufficient to interfere with general recom-

mendations regarding the proper treatment for this insect. Any suggestion made in this article must of necessity be somewhat general in its nature to admit of being applied in all parts of Georgia.

The principal valuable preventive and remedial measures will be discussed under separate heads, based largely on the life history of the insect as already described.

(1) **Wrapping**: Trees may be wrapped about the trunk with brown paper or newspaper, to a height of eighteen inches. This wrapping should be fastened about the top with small wire or stout twine, to prevent larvae from entering under the paper from above. The wrapping should be put in place by August 1st, at the latest, as it is intended to hinder the first born larvae from reaching the trunks of the trees. Tarred paper might be employed, but as it is only intended to remain for three months some cheaper paper will answer about as well.

(2) **Mounding**: After the paper covering is in place the soil should be immediately mounded about the base of each tree, ten inches high, covering the lower portion of the paper. Where trees are treated in this way the larvae hatching from eggs high up on the trunk and main limbs, after dropping to the top of the mound, will be forced to reach the trees through the paper wrapping, and at a point ten inches above the level of the ground. Before the little larvae succeed in affecting an entrance, many will be devoured by ants and birds. Ants are often our best friends by capturing many little borers soon after hatching and before they have been able to tunnel under the bark, where they would be protected.

(3) **Worming**: After the above treatment, wrapping and mounding, has been attended to by August 1st, as recommended, it might seem that the trees would be thoroughly protected. That is not always true, however, as some larvae may get down under the paper wrapping from above, and some may succeed in forcing an entrance through the paper at the surface of the mound. For these reasons alone, *worming should always follow* wrapping and mounding. This worming should begin the last week in October, for it has been shown that nearly all the eggs are hatched by October 15th. The reason for worming at this time is to get as many young larvae as possible before they have injured the trees. Worming at this time will necessitate removal of the paper

wrappings, and leveling of the mounds. In fact, to leave the paper on longer in any event, would be to offer protection to the young borers underneath. A knife will not be required for worming as a great per cent. of the larvae present will be on the surface of the bark feeding on tender spots and covered with a mass of gum mingled with excrement and borings. This gummy mass, together with the worms beneath, may be scraped off with a curved bill-hook arrangement, bluntly pointed at one end and provided with a double edge which should not be sharp—about like a dull table knife. This hook may be heavy enough to serve for digging and cutting if desired, and should be provided with a substantial handle about twelve inches long. With such a hook trees can be wormed rapidly. The majority of the young borers will be found on the tree trunks several inches above ground and being for the most part on the surface, they may be easily scraped off.

The hook mentioned above is one recommended by Mr. C. M. Porter, of Douglas, Ga., and the writer believes that no better implement has been devised for this work.

(4) Caustic and Deterrent Washes: After worming in fall some form of caustic wash should be applied to the tree trunks to kill the larvae which have been exposed, but remain on the trunk, and to prevent the dislodged larvae from re-entering the trees. It appears to be somewhat doubtful about a wash applied earlier in the fall preventing the adults from depositing eggs. Prof. Starnes reports that eggs are laid on the lateral branches: this habit has also been observed by the writer. I have seen moths deposit eggs on the leaves of nursery stock at least three feet above the ground. Washes of a deterrent nature applied to peach tree trunks before the moths appear would probably cause more eggs to be laid higher up and unless the wash applied is capable of repelling the little larvae when hatched, it would be of little value.

Lime-Sulphur-Tar Mixture: A wash that has proved fairly satisfactory, having both deterrent and caustic properties, is one first recommended by Prof. W. M. Scott. It is made as follows: Slake one bushel of lime with a small amount of warm water. While the lime is slaking add ten pounds of sulphur, previously stirred into a paste. To this mixture add one-half gallon of gas tar and then dilute with water to about 50 gallons. This wash carries sufficient lime to form a good coating over the bark, while

not being thick enough to flake off badly when dry. By adding two pounds of Paris green to the above we have a deterrent, caustic and poison wash.

Hale's Borer Wash: Mr. J. H. Hale, President of the Hale Georgia Orchard Co., recommends the following wash: Two quarts of strong soap and a half pint of crude carbolic acid, with two ounces of Paris green, are thoroughly incorporated in a bucketful of water, and enough lime and clay added to make a thin paste.* A wash of this description, if applied about July 15th, would act as a deterrent and poison. To be most thoroughly effective it should be applied to the trunk and main limbs and be replaced when loosened by rain.

Prof. Starnes reports that he cannot recommend any one wash in view of his experience with many different formulas. For applying to trees just after fall worming he recommends the following:

Lime and Potash Wash: A simple mixture of thick whitewash and ball potash—1½ pounds lime, 2¼ ounces caustic potash to the gallon of water.

It is quite probable that the lime-sulphur mixtures recommended for San Jose scale treatment may be used with good success. They certainly possess the caustic property necessary to kill young borer larvae and by adding a little more lime than the scale formula calls for, it would cover tree trunks sufficiently to act as a deterrent to both the adult moths and the larvae.

Summarizing the remarks regarding borer washes, none are worthy of unrestricted recommendation. The best time to apply any wash is just after the fall worming. If washes are applied earlier and before the trees are wormed they should be sufficiently thick and caustic to repel larvae which attempt to enter the trunks of the trees.

(5) Spring Worming: In view of the information now at hand regarding the life history of the peach-tree borer it does not appear advisable to depend on spring worming. The borers are all under the bark in spring and must then be removed with a sharp knife or killed in their burrows with a wire probe. Where other measures have not been properly attended to, spring worming may be necessary and beneficial. It would at least tend to reduce the num-

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*Formula from Cir. 54, p. 4, Bur. of Ent., U. S. D. A.

bers of adults appearing in fall, and prevent much injury during summer months. In general it would seem preferable to devote considerable time and work to the fall treatment as already described, and if some borers have escaped they should be dug out in early spring. A caustic wash may be applied after the spring worming but it will only destroy larvae which have been exposed but not actually killed.

Best results in controlling peach borers will be obtained only when the various remedial measures—as suggested—are combined, and each feature of the work given careful attention.

THE FRUIT-TREE BARK-BEETLE.

(*Scolytus rugulosus* Ratz.)

(Known also as shot-hole borer.)

Next to the Peach Borer this is the most troublesome boring insect attacking the peach in Georgia. During some seasons very little injury is occasioned by this insect, but during the season of 1905 reports came in to the entomologist mainly during the latter part of June and throughout the month of July, from which it was evident that the bark beetle was more than usually abundant in the peach orchards. Several of these reported cases were investigated by a member of this Department, with the result that we became convinced of the unusual numbers of this insect. While the actual damage to healthy trees was not as great as many fruit growers were led to suppose, the appearance of these beetles in great numbers caused considerable alarm, which might easily have been avoided had the true habits and life-history been known. Hence a somewhat extensive description is deemed advisable.

Historical: This insect is a native European species. In the United States it was first noticed in 1877 in New York, where it was attacking the peach. No doubt many other localities were infested at the same period though not then discovered. It has now been found in all the Eastern States and at least as far west as Kansas. This insect has been known to injure the following fruits: Plum, cherry, apricot, nectarine, apple, pear and quince, as well as the peach.

Habits and Nature of Injury: Early writers usually held to the opinion that the fruit-tree bark-beetle would not attack perfectly

healthy trees, and some there are who will still assert that the first writers were correct. Their statements, however, are not borne out by observations made in Georgia peach orchards, as many growers will bear witness. F. H. Chittenden,* writing in 1898, cites cases where this insect had been known to attack apparently healthy trees, where they adjoined old and abandoned orchards, and J. M. Stedman† states that he has seen peach trees, which were to all appearances perfectly healthy, seriously attacked by the fruit-tree bark-beetle. The writer has upon several occasions found the bark-beetles boring into sound, healthy trees. Two such observations were made in Maryland in 1901-02, and in Georgia the same thing has been observed several times.

Fig. 13.—Work of Fruit-tree Bark-beetle in twig—natural size. (After Chit., U. S. Dept. of Agr., Bur. of Ent., Cir. No. 29.)

The weight of evidence is conclusive, however, that the bark-beetles first attack weakened and dying trees, but often when numerous, turn their attack to trees which are apparently in good health. As appropriately stated by J. M. Stedman:‡ "It is very largely a matter of opinion when one pronounces a tree perfectly healthy that has become infested with this pest, but no doubt one should regard a tree as healthy when there is absolutely no reason to suspect anything different except that it has now become attacked by this insect."

The fruit-tree bark-beetle works for the greater part of its lifetime under the bark of the infested tree. A tree in which this insect has been breeding will show many branches like Fig. 13, illustrating the nature of the work under the bark, as well as the outward appearance, showing the holes made by the adult beetle. Young peach trees often commence to wither and dry up towards the end of the limbs before any other sign of borers is discovered. When that occurs the insects will often be found beneath the bark as described farther on.

*Bureau of Entomology, U. S. D. A., Cir. SS. 29.
†Missouri Agri. Exp. Sta. Bull. No. 44.
‡Loc. cit.

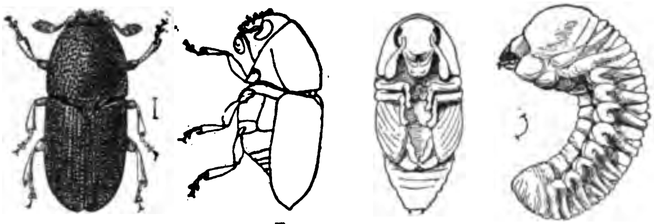

Fig. 14.—Fruit-tree Bark-beetle: a, adult beetle; b, same in profile; c, pupa; d, larva, all magnified about ten time. (After Chit., U. S. Dept. of Agr., Bur. of Ent., Circ. No. 29.)

Description: The adult fruit-tree bark-beetle is a small cylindrical beetle, about one-eighth inch in length and only about one-third as broad. They are uniformly black in color except the tips of the elytra or wing covers and a portion of the legs, which are dull red. Fig. 14, a, illustrates the peculiar punctuation on the thorax and wings, and the peculiar blunt shaped abdomen is well shown in Fig. 14, b. The young borer or grub is white except for the brown head, as illustrated at d. The pupa—the form assumed by the larva just before changing to the adult beetle—is pictured in the figure at c.

Winter Stage and Life History: The winter is passed by this insect in the larval or grub stage in their channels under the bark. In spring about the middle or latter part of March, the parent beetles eat their way out from under the bark, making little holes scarcely 1-16 inch in diameter. These parent beetles soon commence to bore into the trees, and begin the construction of an egg chamber which is nearly always formed in the direction of the long axis of the limb, or nearly so. They seem to prefer to enter at the base of the limbs, or at the forks made by lateral spurs, and often at the base of buds near the extremities of the small branches. The beetles are frequently found, on badly infested trees, entering the trunk nearly to the base of the trees. The egg chamber is formed partly in the cambium layer and partly in the wood directly beneath. An egg chamber varies from one inch or less to an inch and a half in length, and as it is formed minute side pockets are constructed to each side, in which eggs are deposited. It is supposed that each female lays about eighty eggs. The minute grubs hatching from these eggs burrow at right angles to the egg chamber. When a limb is badly infested these channels cross and recross one another, until the cambium layer of bark, and the wood just beneath, is reduced almost to powder. The typical egg chambers and side galleries are well illustrated in Fig 15. The young grubs continue to feed as described until full grown when they make a slightly deeper burrow and there change to the pupae from which emerge the adult beetles as already described. These beetles escape by simply eating their way out through the bark, making the characteristic round hole. As each beetle must make a hole through which to escape and another when entering to construct the egg chamber, the great numbers of holes found in an infested limb are easily accounted for.

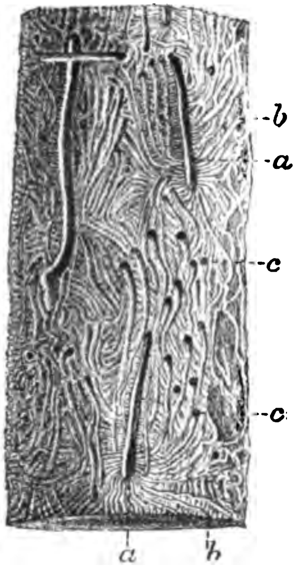

Fig. 15.—Bark removed from twig, showing egg chambers and galleries of Fruit-tree Bark-beetle: a, a, main gallery; b, b, side or larval galleries; c, c, pupal cells —natural size. (From U. S. Dept. of Agr., Bur. of Ent., Circ. 29.)

Generations Each Year: Concerning the number of broods in Georgia each year, no definite observations have been made. In Missouri, Prof. Stedman found three and sometimes a fourth. Considering the fact that many adults were observed this year during the early part of July, and as these must have been the third brood, it is reasonable to predict that we have four generations to contend with in the peach orchards of Georgia.

REMEDIES.

Clean Culture: As heretofore stated the bark beetles seem to prefer to breed in dying trees. Herein will be found the clue to a remedy, or more properly speaking, prevention. All dead and dying trees should be destroyed by burning during winter. This work must be done at least before the first of March in order to destroy all the young borer larvae hibernating under the bark.. All adult beetles—it is generally supposed—die during winter, hence if all wood containing young borers is destroyed there will be practically no borers left to re-infest the orchard the following spring. Of course, there will always be a few slightly infested trees left, and from them some adult borers will develop. A small number of adults in March may increase to considerable numbers by the time the second and third broods appear. In addition to burning all brush and dead trees during winter, the orchards should be closely watched during summer, and when infested trees are discovered or even single infested limbs, they should be removed and burned.

Fertilizing and Cultivating: Slightly infested trees will sometimes recover, after the attacked portions have been removed. To aid this recovery the orchardist should cultivate and fertilize as appears necessary to keep the trees in a healthy, vigorous state of growth. Very healthy trees are more able to withstand an attack

from the fruit-tree bark-beetle, than are poorly nourished, slow-growing trees.

Washes: Understanding the life history of the bark-beetle as already described, one will readily perceive that the application of washes either poison or deterrent, cannot be expected to prove of certain value. The larvae working beneath the bark cannot be killed by any exterior application, and the adult beetles do not feed over a sufficient area of the bark to insure successful poisoning. A deterrent wash, one that will repel the beetles, is therefore the most promising. By adding poison to whatever wash is used some beetles may be killed if they attempt to reach the bark through the wash.

The writer has not been enabled to test the value of the washes that have been recommended by various writers. One that has given fairly good success in Missouri, recommended by J. M. Stedman, is as follows:

Deterrent and Poison Wash.

Dissolve as much common washing soda as possible in six gallons of soft water, and then dissolve one gallon of ordinary soft soap in the above and add one pint of crude carbolic acid and mix thoroughly. Two pounds of lime is then slaked in two gallons of water and filtered so as to remove all dirt and small lumps; this is now added to the above and mixed; while to all is added one-half pound of Paris green or one-fourth pound of white arsenic, and thoroughly mixed.

The above wash will act as a repellant to keep the adult beetles from boring into the trees to deposit eggs. It will not kill the young grubs under the bark. It may poison a few beetles if they attempt to eat through. The trunk and large limbs of trees to be protected must be kept thoroughly covered with this or any other wash which should be applied about the first of March and as often thereafter as necessary to keep the trees well protected. The first application may be made with a spray pump and then every portion of the tree should be covered. Later applications cannot well be applied to the smaller branches and twigs and for that reason it cannot be thoroughly effective.

Wherever orchards are sprayed with lime-sulphur wash for the San Jose scale it is probable that no other wash will be necessary, or at least would not be practical in view of the additional expense.
at least would not be practical in view of the additional expense.

THE PEACH TWIG BORER.

(*Anarsia lineatella* Zell.)

Early in spring the orchardist may be looking through his peach

orchards and notice that many of the young shoots of the new growth are dying back a few inches at the tips. He will wonder what the cause of this trouble may be. Upon examning the dying twigs a slender brownish worm may be found in the little twig just about at the point where the twig commenced to die. This will usually prove to be the larvae of the peach twig borer. This insect is quite common in many parts of this State, though many peach growers are not aware of its identity.

The peach twig borer is evidently a native of Europe and was probably brought to this country on some shipment of nursery stock. It was first regarded as an important peach pest about the

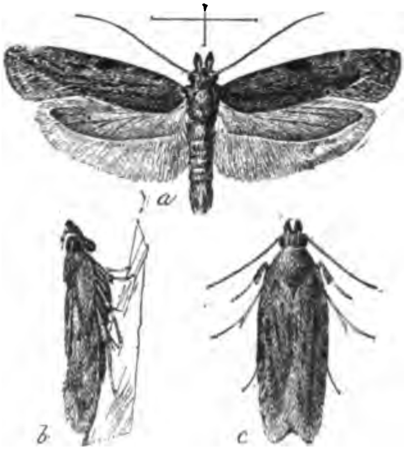

Fig. 16.—Peach Twig Borer: a, moth with wings spread; b and c, same with wings closed, illustrating normal position. (After Marlatt, U. S. Dept. of Agr., Bur. of Ent., Bull. No. 10.)

Fig. 17.—Peach Twig Borer: a, new shoot of peach dying from attack of larva; b, larva enlarged; c, pupa enlarged. (After Marlatt, U. S. Dept. of Agr., Bur. of Ent., Bull. No. 10.)

year 1872, according to Marlatt,* when it was reported as causing excessive damage in young peach orchards in Maryland. It has since been reported from many of the peach growing states, and will, in time, if not already so, become cosmopolitan in its distribution.

Description and Life History: The adult moth is shown in Fig. 16 in the natural position, as when resting on a branch, and with the wings spread to show the characteristic markings. These moths appear in early summer from the worms or larvae causing the

* U. S. Dept. of Agr., Bur. of Ent., Bull. No. 10.

first dead twigs as mentioned above. The first brood of moths soon commence to deposit eggs around the base of the new leaves as described by Prof. C. L. Marlatt,* and from these eggs minute larvae hatch, at first very small, pale yellow in color, with black extremities. These larvae proceed at once to bore into the shoot on which they are located. Sometimes they enter the shoot and burrow for a short distance in the center; these burrows being from one-fourth to one and one-half inches in length. Or they may simply bore to the center of the shoot, and, apparently dissatisfied with the location, wander away to another shoot. Thus a single larva may bore into and injure several new twigs in the course of its wandering life. The writer has observed many such cases; a twig often showing only a small hole with no sign of the intruder, though the twig was found in a dying condition. In California it is claimed that the summer broods attack the growing peaches, but this injury has not been noticed in Georgia, so far as the writer is aware.

The larva or worm attains a length when full grown of nearly one-half inch; color dull reddish brown, with the head and posterior end dark brown or black. The body tapers toward either end and is sparsely clothed with long hairs. (Fig. 17, b.) When grown the larvae spin a scanty web in the leaves or rubbish about the trees or even in the dried leaves of the injured shoot. In this web the larvae change to the pupae (Fig. 17, c), from which the adult moths emerge.

Winter Stage: It has been determined that there are probably four broods. The larvae of the last brood seek their winter quarters, and this point in their life history is of great importance as it offers a chance for easily destroying most of these insects during winter. It has been found by Prof. Marlatt that the larvae of the last brood construct small silken cells in the spongy bark at the crotches of the branches of the peach, and there pass the winter. In these quarters they are only poorly protected and often fall prey to birds and predaceous insects, and they are also frequently killed by a parasitic mite.

*Loc. cit.

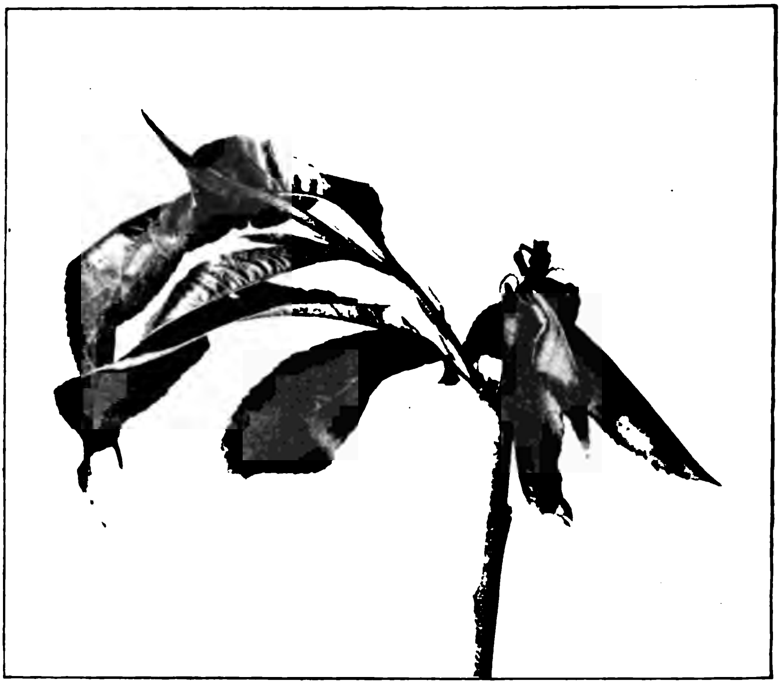

Fig. 18.—Terminal twig of peach tree killed by larva of peach twig-borer. (Photo. by A. C. Lewis.)

REMEDIES.

It would at first thought be supposed that the larvae could be trapped when the first dying twigs appear in summer by simply cutting off the injured shoots, and by burning, destroy the larvae within. This is in fact a possible remedy, but as stated above, a single larva may injure several twigs; hence many twigs might be removed to capture only a few of the insects. Furthermore the larvae attain full growth in about two weeks so that the time during which the worms could be trapped is comparatively short.

The larvae passing the winter in the crotches of the trees are easily killed by a spray of lime-sulphur wash as advocated for the San Jose scale. In California this insect is effectually controlled by the winter treatment. Wherever trees must be sprayed for the San Jose scale or other scale insects, the Peach twig borer will be so reduced by the treatment that they will not cause serious trouble. Young peach trees could be washed or painted with the

lime-sulphur wash where it is not necessary to spray the entire orchard.

THE CURCULIO.

(*Conotrachelus nenuphar* Hbst.)

Wormy peaches are nearly always found in every peach orchard each year, and much fruit is ruined and thrown away on this account. By far the majority of the worms occurring in peaches in Georgia are the larvae of the Curculio, usually named "plum curculio."

The adult curculio or beetle is commonly called "The little Turk." Owing to its small size this insect is not generally observed by the average fruit grower though the worms occurring in the fruit and the marks on the skin are familiar objects.

Description: The curculio, or weevil, as it is sometimes called, is a small, dark brown, rough backed beetle, looking like a dried bud when shaken from the trees, which resemblance is increased by its habit of drawing up its legs and remaining for a time without motion, seemingly lifeless. In other words, this beetle when disturbed will play "possum," and when in that position it is indeed hard to distinguish from a small dried bud. The color is dark brown variegated with white, ochre-yellow and black. The wing covers have short ridges, those in the middle of the back forming two humps which are shiny black; just behind the humps there is a wide band of ochre-yellow and white. The beetles vary in size but average nearly one-fifth inch in length. They are provided with membraneous wings—under the visible wing covers as described above—with which they fly easily for considerable distances.

Habits and Life History: The beetles pass the winter under protection of weeds, rubbish, etc., in the orchard, under and around peach trees, and also in the leaves and brush in the edge of forests, which frequently adjoin the peach orchards. In spring when peach trees are just pushing out the tender buds, the curculio emerge from their winter quarters and commence to feed on the opening buds. Mating soon takes place and by the time the first fruit is set the females are ready to deposit eggs.

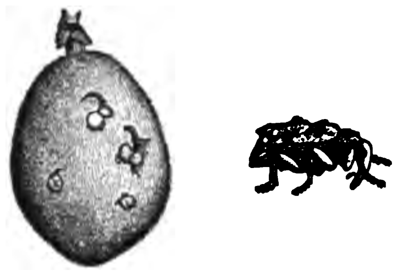

Fig. 19.—The Curculio: Egg punctures on peach—natural size; adult beetle, on right—enlarged. (From U. S. Dept. of Agr., Farmer's Bull., No. 33.)

The egg puncture made by the female curculio is very characteristic on plums but not as distinct on the fuzzy skin of the peach. (Fig. 19.) Before depositing an egg the beetle first makes a small crescent-shaped incision with the snout, which she also employs to force the egg under the skin. Only one egg is deposited in a place, and as long as plenty of peaches remain unstung only a few will be found with more than one egg puncture. If fruit is scarce several eggs may be found in a single peach.

The eggs thus deposited soon hatch into white, footless grubs which commence to bore toward the center of the fruit, finally lodging near the seed. Such infested fruit often drops when about the size of a grape. Oftentimes a peach may attain a size of nearly one inch in diameter before being stung, and may then develop and ripen prematurely even with a worm within, constituting the common "wormy" fruit. The irritation arising from the egg punctures and the gnawing of the young grubs causes the fruit to become gummy, diseased, and either ripen prematurely or form imperfect fruit. Frequently small holes are eaten in the peaches simply for the purpose of feeding, and from the wounds thus inflicted the gum often exudes, and rot frequently sets in at the injured spot, thus causing much additional injury.

In fallen, wormy fruit the grubs complete their growth and after leaving the fruit enter the ground and pupate. In about three or four weeks the adult beetles develop from the pupae. It is generally supposed that there is only one brood each year, though this fact has not been definitely established. The egg laying period of a single female may extend over eighty days, which accounts for the fact that small worms are found in nearly mature peaches. It is also possible that a partial second brood occurs in South Georgia.

REMEDIES.

Jarring: This is one of the oldest recommendations and possibly the best even at the present time. Taking advantage of the

fact that the adult curculio will curl up and drop when disturbed, it is possible to capture large numbers by jarring trees over a sheet, from which the beetles can be collected and destroyed. Many devices have been suggested for capturing the curculio in this way. One is a patented affair, shaped like an inverted umbrella with a slit in one side in which the trunk fits when the arrangement is pushed under the tree. This device is fitted with one wheel and handles like a wheel-barrow. After this arrangement is pushed under a tree the trunk is hit a couple of sharp raps with the padded end of a pole. The curculio thus disturbed, drop to the slanting sheet from which they slide to the center and drop into a can containing a little kerosene. The worst objection to such an outfit is that all insects, including many beneficial lady-bugs, are often destroyed along with the curculio.

Fig. 20.—Jarring for Curculio. Method employed by Hale Orchard Co., Ft. Valley, Ga. (Photo. by author.)

The Hale Orchard Co., Fort Valley, Ga., have a simple arrangement, which has been used with success. Two light wooden frames are made, each about 6x12 feet, and in the side of one frame a cut is made, large enough to accommodate a tree trunk. These

frames are covered with stout cotton cloth and when placed under a tree, with two of the long edges together, a broad surface is secured, which will catch every insect dropping from the tree above. A padded pole is used for jarring the tree. It requires five men for each outfit, two for each frame and one to jar the trees. By having several double frames and a large force of negroes a large orchard can be covered in a few hours. Jarring should commence early—at first break of day—and be vigorously performed until about half-past eight in the morning. Later than this hour many of the curculio will be hiding in the rubbish under the trees and thus escape. An orchard can be quite thoroughly protected by jarring every morning after the fruit is first beginning to set, continuing the work as long as the beetles are numerous. After the first few days, where the work is thoroughly done, the beetles will become quite scarce.

The advantage of this jarring method over the patent device is that it is cheaper, and the curculio can be collected from the sheets without destroying the beneficial insects.

Spraying: Authorities differ regarding the value of poison sprays for killing curculio. It is an unquestionable fact that the curculio feed to some extent on the opening buds and also on the fruit; but experiments have not demonstrated that many beetles can be poisoned by spraying. The new buds develop so rapidly that it is almost impossible to keep them covered with poison spray, and by the time the foliage is fully formed the peaches are also large enough to offer food to the adult curculio. Thorough spraying will, however, poison a certain number of beetles, and for this work it would be well to use Paris green in connection with Bordeaux mixture, 4 ounces of Paris green to each barrel. Or arsenate of lead may be used, 2 pounds to 50 gallons of water, or in the same proportion with Bordeaux mixture.

Gathering Fallen Fruit: This should properly be called prevention, as it tends to reduce the number of adult curculio developing each season. It is of great importance to prevent curculio from increasing from year to year. All fallen fruit should be gathered and destroyed by burying or feeding to hogs. This practice is of considerable value by destroying rotten fruit as well as the curculio. Even in orchards where spraying and jarring have been practiced it would be advisable to gather all fallen fruit.

This must be picked up every few days to prevent the larvae from leaving and entering the ground.

Clean Cultivation: This hinges closely on to the foregoing paragraph as gathering fallen fruit is really a part of clean cultivation. The adult beetles hide during winter in rubbish, weeds, etc., hence all such harboring places should be prevented by keeping orchards clean and free from weeds and brush. Forests immediately surrounding orchards offer abundant winter protection to the curculio, and where the damage would not be too great a portion of these forests adjoining the orchards should be burned over each winter, which would result in destroying hundreds of over-wintering curculio.

PLANT LICE INJURIOUS TO THE PEACH.

Under this head we have several species, all closely resembling each other in size and shape, though often differing in color. Some species differ quite widely in habits and life-history, and also in appearance if submitted to close scrutiny. As the treatment recommended for this family of insects is about the same for one and all, and the description of one or two species will serve to illustrate the variation in life history, for the purpose of this bulletin it is not deemed necessary to mention all the different species that might attack the peach.

Indication of Aphis: When peach trees in early spring or summer are discovered with the tips presenting a dwarfed growth, and with the leaves curled and twisted, aphis may be looked for. These will be found on the underside of the curled leaves and often clustered in great numbers around the tender shoot and terminal bud. Hundreds of individuals may occur on a single leaf as a single aphis is less than 1-10 inch in length.

THE NEW PLUM APHIS.

(*Aphis Scotti* Sand.)

Although this species has been named "Plum Aphis," it is by no means confined to the plum. Our first knowledge of this particular species dates back to 1898 when it was discovered by Prof. W. M. Scott in a plum orchard at Fort Valley, Ga. During that year and the one following it was observed on plum and peach, causing considerable injury to the growing tips of young trees, and particularly to nursery stock—June-budded peach. In 1899 Prof.

Scott determined the life history in general and since then it has been considered as an important peach insect.

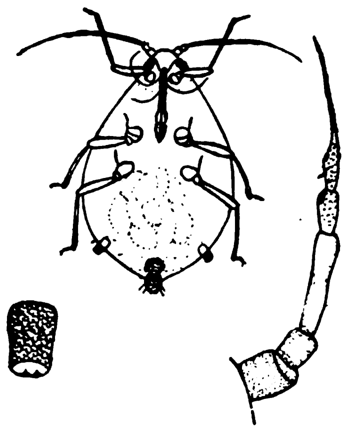

Fig. 21.—Stem mother of New Plum Aphis. (After Scott, U. S. Dept. of Agr., Bur. of Ent., Bull. No. 31.)

Life History: The winter is passed in the egg stage, these eggs being found scattered over the terminal shoots. From these eggs, which are dark brown in color, and very small, small wingless lice hatch, appearing just about as the buds commence to open in spring. Within a short time these young lice reach maturity and become "stem mothers." (Fig. 21.) Each individual is an agamic female capable of giving birth to living young without the intervention of the male. Each stem mother gives birth to several young, which in turn reach maturity and bring forth more young in a like manner. The majority of these develop into agamic females resembling the stem mother, though some individuals develop wings and fly to other localities where they establish new colonies. These winged agamic females (Fig. 22) give birth to young re-

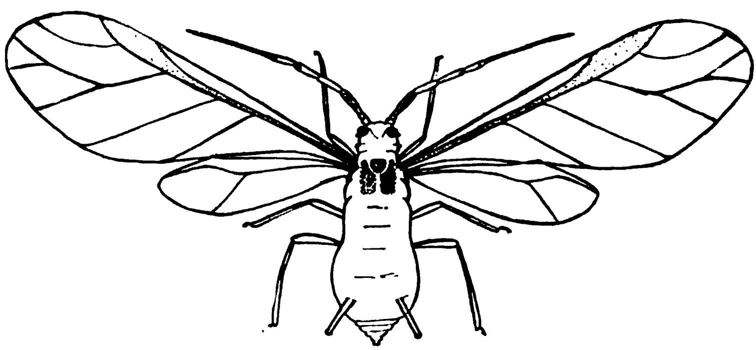

Fig. 22.—Winged form of New Plum Aphis. (After Scott, U. S. Dept. of Agr., Bur. of Ent., Bull. No. 31.)

sembling those from the stem mother. During the season there may be ten or more generations, as described above. From the last generation each season true males and females develop, which mate, thus providing for the winter eggs.

It is no uncommon sight to see a stem mother surrounded by a hundred or more aphis of all sizes. By sucking the plant juices the leaves are made to curl and twist, always toward the side on which the lice are located. When the leaves become badly curled it will be readily understood that the lice are well protected and hard to reach with any insecticide. This characteristic curling of leaves should be carefully noted as it is closely connected with the subject of remedies which will be considered after mention has been made of one more species of aphis.

THE BLACK PEACH APHIS.

(*Aphis persicae-niger* E. F. Smith.)

Description and Life History: This species, as its name implies, is shining black or deep brown in color. Winged and wingless forms both occur, new colonies being established by means of the former. The young aphis are faint greenish-brown, becoming darker as they near maturity. All these forms will be found on the growing tips of infested peach trees in early spring causing the leaves to curl in the characteristic manner.

Unlike the plum aphis this species does not winter in the egg stage. About mid-summer many of the aphis on the leaves and branches make their way to the ground and to the roots where the winter is passed. Dr. John B. Smith* states that no males have been observed and no eggs have been discovered; hence it is assumed that the black peach aphis breeds agamically all the year round. Early in spring the root form make their way to the surface and to the branches, and there colonies are formed on the opening buds, later living on the fully developed leaves and tender stems.

REMEDIES.

Plant lice live by sucking the plant juices, and for that reason they cannot be poisoned with arsenicals. Contact poisons must be employed for these insects. For the forms which occur above

*N. J. Exp. Sta. Bull. No. 72.

ground we have a simple remedy, as kerosene emulsion at 15 per cent. strength or a strong soap solution will kill all the aphis with which it comes in contact. Now it will be seen why the matter of the curled leaves becomes significant. It is almost impossible to spray a tree with emulsion, or any solution, so as to reach all the aphis inside the curled leaves. This can only be affected by dipping, which is out of the question with orchard trees of any size, though it may be practiced with nursery stock. By watching closely for the first appearance of aphis in spring the first colonies may be discovered and destroyed by spraying before the leaves become curled. If many leaves are curled when the infestation is first discovered, it may become necessary to gather the badly curled leaves by hand, and follow with the emulsion to destroy all remaining aphis. (For preparing kerosene emulsion see directions on page 69.)

Whale oil soap solution, 1 pound to 3 gallons of water, will be found as effective as the emulsion; or tobacco decoction may be prepared by boiling 3 pounds of tobacco leaves or stems, in 5 gallons of water for about three hours. This decoction may be used without dilution and will prove very effective.

The black peach aphis occurring on the roots of peach trees will seldom become serious if the form appearing above ground is properly destroyed each year, at least enough to reduce them to insignificant numbers. The greatest danger is that this insect may be spread on nursery stock, but even that danger is mitigated by fumigation which is required of all nurserymen in Georgia. Liberal applications of tobacco dust about the roots of nursery stock is valuable for destroying the root form of peach aphis.

Any plant lice occurring on leaves or branches may be killed by spraying with the contact insecticides mentioned above, and no one need fear this form of insect if the first colonies appearing in spring are properly destroyed.

ROOT KNOT OR NEMATODE GALL.

While not an insect, strictly speaking, the nematode worm, which is the cause of root knot on peach trees should be mentioned in connection with other peach insects. These knots are caused by a small "eel-worm" or nematode, an individual being almost microscopical in size; but the knots resulting from their attack are readily noticed. (Fig. 23.) A close examination of fresh knots will usually reveal the little cavities containing eel worms in all stages of development.

In Georgia it has been observed that the root knot is most

prevalent on trees in sandy soils, such as are found in some parts of South Georgia, while in the stiff clay lands this trouble is seldom noticeable.

The symptom of root knot, which can be seen above ground, is usually a scanty yellow growth. Young trees often die from the effect of root knot during the second or third year, but where older trees are attacked they may survive for several years or almost indefinitely, although making a poor growth.

No good remedy for this trouble is known though much damage therefrom may be avoided by adhering to certain rules.

In the first place orchardists should not plant trees bearing roots which show root knot; or if only a very little is present it should be carefully pruned off before planting. Another thing that should be understood is that the nematode worms live on several common garden and field crops, such as cabbage, okra, turnip, egg-plant, cotton and cow-peas. In the case of the cow-pea we have an exception in the variety of pea known as the "Iron" cow-pea. This variety is practically resistant to the nematode worm and can be planted with safety in the peach orchard, and in view of the fact that so many cow-peas are grown in the Georgia peach orchards, it is fortunate that we have this resistant variety. All plants which are susceptible to attack from the nematode worm should be kept out of peach orchards where the worms are known to occur. This practically results in a starving out process.

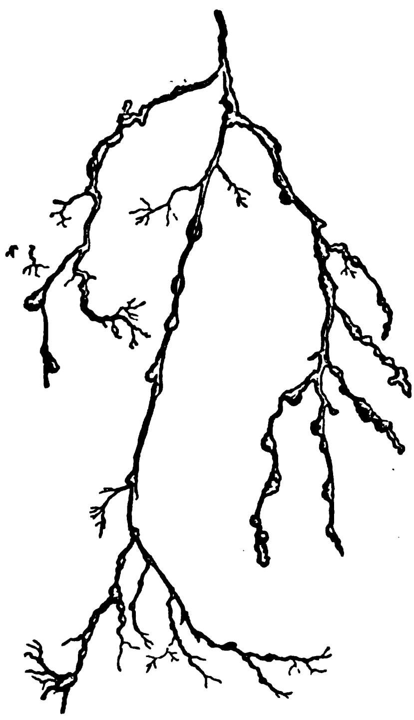

Fig. 23.—Root Knot on peach root caused by "eel worms" or nematodes. (From U. S. Dept. of Agr., Farmers' Bull. No. 33.)

Insecticides are of little if any value against the nematode worms. In Florida it was found that heavy applications of potash fertilizer, either sulphate or muriate, 3,000 lbs. per acre, were of some value

but the large amounts necessary make their use prohibitive.

It has been suggested that nematode worms may be destroyed by heat, and this may be practical over small areas, especially where only an occasional tree is infested. Under such conditions each infested tree should be dug up by the roots leaving a fair sized hole, above which a pile of brush and wood could be burned. Afterward by filling the hole with fresh earth from an uninfested field, another tree could be planted in place of the old one. This tree would be able to develop a strong, vigorous root system before the nematodes again became abundant.

As a general thing it will not be profitable to plant a peach orchard in land where the nematode worms are abundant, as long as uninfested land can be selected. Land once infested will remain so for several years, but the worms will die out gradually if the land is planted in corn, or some such resistant crop.

CATERPILLARS.

Caterpillars are not as a rule a serious enemy of peach trees. Every year, however, a few outbreaks occur, but the damage to trees in Georgia in the past few years has been almost of no consequence. A few words, however, in this connection may be of interest.

THE AMERICAN TENT-CATERPILLAR.

(*Malacosoma americana* Fabr.)

Every one is familiar with the white webs of the tent-caterpillar, which are found on wild cherries and apples in spring, and which increase in size at an alarming rate. This ten-caterpillar sometimes attacks peach trees, and although easily destroyed they are often allowed to work unmolested.

Life History and Habits: During winter the eggs may be seen on the small twigs where they occur in a mass, encircling the twig. Each mass contains over two hundred eggs which are glued tightly together and covered with a glutinous matter which gives the mass a glistening brown color. The mass of eggs is usually about three-fourths inch in length and a little thicker than a heavy plain gold ring.

In spring the little caterpillars hatching from these eggs commence at once to form a web in the nearest crotch. As the caterpillars increase in size the nest is enlarged until it becomes a very conspicuous object. The caterpillars feed during the day time, leaving the nest for this purpose. During rainy or cloudy days they seldom wander from the nest.

When full-grown these caterpillars attain a length of about two inches; body quite hairy, and ornamented with a continuous white stripe along the back, while on either side short yellow stripes occur somewhat irregularly. Each caterpillar changes to a pupa in a yellow loosely constructed cocoon which is usually located in some protected place such as a fence corner.

REMEDIES.

The egg masses may be found during winter while the trees are bare. In spring if trees are closely watched, the little webs may be found while the inmates are still very small. These nests should be cut out and burned or crushed by hand. Such work, however, must be done in early morning or about sun-down, or on dark cloudy days, as at other times many of the caterpillars will be feeding away from the nest and thus escape.

Other Caterpillars.

The tent-caterpillar is easily controlled without spraying, but some leaf-eating worms are not so easily captured. Whenever the foliage of fruit trees is being destroyed by caterpillars it may be readily protected by spraying with some arsenical poison. Peach foliage is very easily injured by arsenical sprays; hence the foloiwng dilute formula is recommended to be employed against any leaf-eating caterpillars.

Formula:	Paris green or Green Arsenoid----	1 pound.
	Quick lime ----------------------	3 pounds.
	Water -------------------------	175 gallons.

Paris green may also be used in connection with weak Bordeaux mixture, at the rate of 4 ounces of the former to 50 gallons of the latter. One spraying with either of the above mixtures will usually kill enough caterpillars, when present, to prevent their causing any considerable injury.

GEORGIA
State Board of Entomology

BULLETIN No. 18.—DECEMBER, 1905.

PEAR BLIGHT DISEASE

Cause and Prevention

PEAR LEAF BLIGHT

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PEAR BLIGHT DISEASE IN GEORGIA.

By R. I. Smith.

Introduction.

Probably every pear grower in Georgia is well acquainted with the familiar appearance of the blight disease, either through actual experience with it in his own orchards, or from observations made in other orchards. Probably no disease of fruit trees is more evident in its effect or more universally known to all fruit growers. But some perhaps do not know that the common pear blight is identical with the blight of apple, quince, hawthorn and other pomaceous fruits. To scientists this fact has, for a number of years, been known, and this information has been given somewhat wide distribution by the United States Department of Agriculture, through the writings of their expert pathologist, Prof. M. B. Waite.

The necessity and value of putting this information in the hands of all fruit growers in Georgia as well as other parts of the South, has made it seem advisable to reprint the known facts regarding the pear blight disease, and the Georgia State Board of Entomology believes this subject to be of sufficient importance to justify its publication as a bulletin of this Department.

We are indebted to Prof. M. B. Waite, Assistant Chief Division of Vegetable Physiology and Pathology, of the United States Department of Agriculture, for the privilege of reprinting his work which is included herewith under the head of, "Cause and Prevention of Pear Blight."

Its Occurrence in Georgia in 1905.

In the spring of 1905 the pear blight caused an unusual amount of injury to both pear and apple orchards in nearly all sections of the State. In some localities the crop was entirely cut off, while in other sections from 50 to 75 per cent of the

blooms were destroyed by the blight bacteria, which caused what is termed "blossom blight." (This form of blight is more fully described farther on.) The writer knows of one case in particular where the annual income from a certain pear orchard has never fallen below $2,000.00 until this year, when it produced very little over $100.00 worth of fruit. Some apple orchards also failed for the first time, to produce a good crop of fruit. The unusual weather conditions that prevailed at the time apples and pears were blooming were perhaps favorable to a great increase of pear blight, while at the same time the cold weather caused the death of a certain per cent of the opening blossoms. The two conditions combined were undoubtedly responsible for the failure of the pear and apple crops in certain parts of the State, particularly in North Georgia, but in most parts of South Georgia it seems safe to say that the greater part of the injury was caused by the pear blight without the aid of cold weather.

The fact that the pear blight germ enters principally through the bloom—as described farther on—and that last spring's cold weather came at about the blooming period, was the cause of misleading many growers into the belief that the cold weather was the direct cause of the blight disease, and that without this cold weather very little of the blight would have occurred. This inference, however, was not true, except perhaps to the extent that the heavy frosts and freezes rendered the trees more susceptible, causing a condition favorable to the development of the blight disease. As will be shown farther on, however, the blight bacteria are spread by insects principally, and the blight cannot therefore be directly caused by cold weather, or any condition of the atmosphere.

Pear blight was by no means confined to pear trees during the past season; in fact, as has been mentioned, it was fully as disastrous to apples in some sections. Many apple orchards in North and Middle Georgia put on a heavy bloom and gave promise of an excellent crop. At about the time when the petals should have fallen a heavy frost caused some injury, and at about the same time the blossoms were attacked by the blight bacteria with a result that the majority were destroyed. In some sections that the writer visited the entire injury was supposed to be due to unseasonable frosts and continued cold weather, though a careful examination showed unmistakable evidence of the blight disease. This conclusion was in part justified by the fact that trees without bloom did not show dead

twigs, whereas on other trees every twig, bearing a bloom, was killed back from two to ten inches. Cold weather might well be held responsible for the death of many blooms but it could hardly be expected to kill the twig back of the bloom.

What Can Georgia Growers do to Prevent Pear Blight?

This is the question always asked, and one which arises usually after the damage—for the current year at least—has been done. In reply to such questions we must for the present refer those interested to the latter part of this bulletin in which the cause of pear blight is outlined together with remedial suggestions.

It has already been demonstrated in Georgia, in a few localities, that pear blight can be reduced or prevented to a great extent. Orchards which have received proper care in the way of pruning and judicious cultivation and fertilization, from the first year after being planted out, have been practically free from the pear blight. The great trouble has been, and will continue to be, that young orchards are planted in the vicinity of old and neglected orchards in which the blight develops each year, constituting veritable incubating points for the development of the blight bacteria, which under favorable conditions are spread to orchards which would otherwise be free. Those orchards in which very little blight has occurred are the ones which are more or less isolated and where re-infection from other orchards is reduced to a minimum. Naturally in localities where the orchards closely adjoin one another the matter of blight control becomes difficult. But even in such localities a systematic and thorough pruning will offer protection in most years. There may be years like the one just past when conditions are such that pear and apple orchards will be seriously affected by blossom blight, even though the trees have been given proper attention. The difficulty in obtaining success in this work lies in getting every orchard in each section properly pruned.

Proposed Work Against Pear Blight.

The value of the pruning method for controlling pear blight must be demonstrated in Georgia before it can be expected that all growers will take up the work. For the purpose of determining just how much good will result by giving pear trees proper pruning for a number of years, and to make this demonstration in such a way that pear and apple growers will get the

full benefit resulting from an actual illustration, the Georgia State Board of Entomology has taken the supervision of the pruning of pear orchards in a few representative localities. Work of a nature similar to what will be undertaken by this Department has been conducted quite successfully by Prof. M. B. Waite of the United States Department of Agriculture. This work has been carried on for three years at Cairo, Ga., and also at a point in North Georgia. In the State of Maryland orchards have been treated in a like manner with gratifying results.

By a special arrangement, whereby this Department will work in co-operation with the United States Department of Agriculture, the orchard at Cairo, Ga., will be under the supervision of a member of the Georgia Department of Entomology. Demonstration work will also be carried on at Smithville, Ga., which is now one of the large pear growing sections of this State, and similar pruning experiments will be undertaken in the western and northern sections of Georgia. It is the intention of this Department to continue the work, that is now being started in each section, for at least three years. In the meantime, before the work is discontinued, all pear growers who are interested in the result, will have an opportunity of visiting and inspecting the work as it progresses. By such an arrangement it is hoped that this work will prove to be of peculiar value to the pear and apple growers of the State.

THE CAUSE AND PREVENTION OF PEAR BLIGHT.

By M. B. Waite.

"There is probably no disease of fruit trees so thoroughly destructive as pear blight, or fire blight, which attacks pears, apples, and other pomaceous fruits. Some diseases may be more regular in their annual appearance, and more persistent in their attacks on the fruits mentioned, but when it does appear, pear blight heads the list of disastrous maladies. Again, no disease has so completely baffled all attempts to find a satisfactory remedy, and, notwithstanding the great progress made within the last ten years in the treatment of plant diseases by spraying and otherwise, pear blight has until recently continued its depredations unchecked. It is now known, however, that the disease can be checked by simply cutting out the affected parts. This was one of the first methods tried in endeavoring to combat the disease, but came to be generally regarded as worthless. The remedy which will be discussed in this paper is, in a general way, so similar to the old one that at first it may be difficult to see that anything new has been discovered. In the process now proposed, however, there are three vital improvements, namely, the thoroughness and completeness with which the work is carried out, the time when the cutting should be done, and a thorough knowledge of the disease so as to know how to cut.

The method of holding the blight in check was discovered through a careful scientific investigation of the life history of the microbe which causes it. The investigations were carried on in the field and laboratory, and extended over several years. In the short account which follows no attempt will be made to enter into the details of the work, nor to introduce all the evidence to prove the various statements, but simply to give such points as will enable the reader to intelligently carry out the method advocated.

WHAT IS PEAR BLIGHT?

Pear blight may be defined as a contagious bacterial disease of the pear and allied fruit trees. It attacks and rapidly kills the blossoms, young fruits, and new twig growth, and runs down in the living bark to the larger limbs, and thence to the trunk. While the bacteria themselves rarely kill the leaves, at most only occasionally attacking the stems and midribs of the youngest ones, all the foliage on the blighted branches must of course eventually

die. The leaves usually succumb in from one to two weeks after the branch on which they grow is killed, but remain attached, and are the most striking and prominent feature of the disease. (See Fig. 1.)

The most important parts of the tree killed by the blight are the inner bark and cambium layer of the limbs and trunk. Of course, when the bark of a limb is killed, the whole limb soon dies, but where the limb is simply girdled by the disease, it may send out leaves again the next season and then die. All parts of the tree below the point reached by the blight are healthy, no more injury resulting to the unaffected parts of the tree than if the blighted parts had been killed by fire or girdling.

Blight varies greatly in severity and in the manner in which it attacks the tree. Sometimes it attacks only the blossom clusters or perhaps only the young tips of the growing twigs; sometimes it runs down the main branches and trunk; and again it extends down only a few inches from the point of attack. The sudden collapse of the foliage on blighted branches has led many to believe that the disease progresses more rapidly than it really does. It rarely extends farther than 2 or 3 inches from the point of attack in one day, but occasionally reaches as much as 1 foot.

It is an easy matter to determine when the disease has expended itself on any limb or tree. When it is still progressing, the discolored, blighted portion blends off gradually into the normal bark, but when it has stopped there is a sharp line of demarcation between the diseased and healthy portions.

CAUSE OF THE DISEASE.

Pear blight is caused by a very minute microbe of the class bacteria. This microbe was discovered by Prof. T. J. Burrill, in 1879, and is known to science as *Bacillus amylovorus*. The following are the principal proofs that it causes the disease: (1) The microbes are found in immense numbers in freshly blighted twigs; (2) they can be taken from the affected tree and cultivated in pure cultures, and in this way can be kept for months at a time; (3) by inoculating a suitable healthy tree with these cultures the disease is produced; (4) in a tree so inoculated the microbes are again found in abundance.

LIFE HISTORY OF THE MICROBE.

Blight first appears in spring on the blossoms. About the time the tree is going out of blossom certain flower clusters turn black and dry up as if killed by frost. This blighting of blossoms, or

FIG. 1. PEAR TREE SHOWING LIMBS KILLED BY PEAR BLIGHT. (NOTICE THE LIMBS ON WHICH LEAVES ARE CURLED AND DROOPING.)
Photograph taken May 29, 1905, Summerville, Ga. Photo by R. I. Smith.

Fig. 2. KIEFFER PEAR ORCHARD, FOUR YEARS OLD. Showing Vase Form of Pruning Practiced by M. B. Waite.
(From Year Book, Dept. of Agr., 1900.)

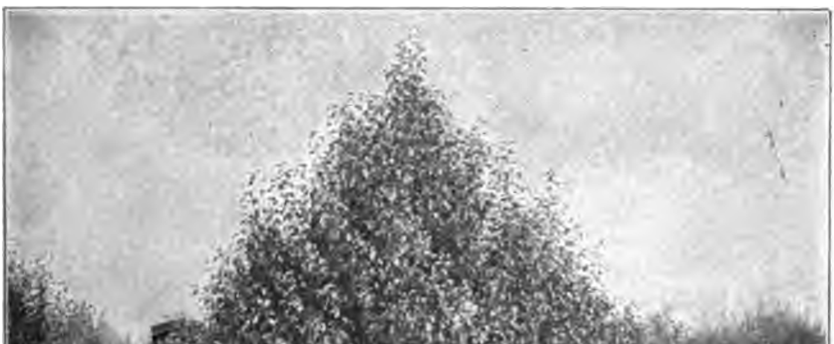

Fig 3. MANNING PEAR ORCHARD. Showing Pyramidal Form of Pruning.
From Year Book, Dept. of Agr., 1900.

blossom blight, as it is called, is one of the most serious features of pear blight. One of the most remarkable things about this disease is the rapidity with which it spreads through an orchard at blooming time. This peculiarity has thrown much light on the way the microbes travel about, which they do quite readily, notwithstanding the fact that they are surrounded and held together and to the tree by sticky and gummy substances. They are able to live and multiply in the nectar of the blossom, from whence they are carried away by bees and other insects, which visit the blossoms in great numbers for the honey and pollen. If a few early blossoms are infected, the insects will scatter the disease from flower to flower and from tree to tree until it becomes an epidemic in the orchard. We shall see later how the first blossoms are infected. From the blossoms the disease may extend downward into the branches or run in from lateral fruit spurs so as to do a large amount of damage by girdling the limbs. Another way in which the blight gains entrance is through the tips of growing shoots. In the nursery, when trees are not flowering, this is the usual mode of infection. This is often called twig blight, a good term to distinguish it from blossom blight, provided it is understood that they are simply different modes of attack of the same disease.

CONDITIONS AFFECTING THE DISEASE.

The severity of the attacks, that is, the distance which the blight extends down the branches, depends on a number of different conditions, some of which are under the control of the grower. It is well known, however, that the pear and quince are usually attacked oftener than the apple. Some varieties of pears, like Duchess and Keiffer, resist the disease much better than others, such as Bartlett and Clapps Favorite. It may be stated in a general way that the trees most severely injured by the blight are those which are healthy, vigorous, well cultivated and well fed, or, in other words, those that are making rapid growth of new, soft tissues. Climatic conditions greatly influence the disease, warm and moist weather, with frequent showers, favoring it; dry, cool, and sunny weather hindering it; and very dry weather soon checking it entirely.

The pear blight microbe is a very delicate organism and can not withstand drying for any length of time. In the blighted twigs exposed to ordinary weather it dries out in a week or two and dies. It causes the greater part of the damage in the month or two following blossom time, but twig blight may be

prevalent at any time through the summer when new growth is coming out. In the nursery severe attacks often occur through the summer. In the majority of cases, however, the disease stops by the close of the growing season. At that time the line of separation between the live and dead wood is quite marked, and probably not one case in several hundred would be found where the diseased wood blends off into the healthy parts and the blight is still in active progress. In the old, dried bark, where the disease has stopped, the microbes have all died and disappeared.

It has been claimed that the blight microbe lives over winter in the soil, and for a long time the writer supposed this to be the case; but after careful investigation the idea was abandoned, for in no instance could it be found there. Unless the microbes keep on multiplying and extending in the tree, they soon die out. This is a very important point, for it affords opportunity to strike the enemy at a disadvantage. In certain cases the blight keeps up a sort of slow battle with the tree through the summer, so that at the close of the season, when the tree goes into a dormant condition, active blight is still at work in it. This is also true of late summer and autumn infections. In these cases the blight usually continues through the winter. The germs keep alive along the advancing margin of the blighted area, and, although their development is very slow, it is continuous. Probably the individual microbes live longer in winter. At any rate, the infected bark retains its moisture longer, and generally the dead bark contains living microbes during a much longer period than it does in summer. It has already been found that this microbe stands the cold well. Even when grown in broth in a warm room they may be frozen or placed in a temperature of 0° F. and not suffer.

When root pressure begins in early spring the trees are gorged with sap. Under these favorable conditions the microbes which have lived over winter start anew and extend into new bark. The new blight which has developed in winter and spring is easily recognized by the moist and fresh appearance of the blighted bark, as contrasted with the old, dead, and dry bark of the previous summer. The warm and moist weather which usually brings out the blossoms is particularly favorable to the development of the disease. At this time it spreads rapidly, and the gum is exuded copiously from various points in the bark and runs down the tree in a long line. Bees, wasps, and flies are

attracted to this gum and undoubtedly carry the microbes to the blossoms. From these first flowers it is carried to others, and so on till the blossoms are all killed or until the close of the blooming period. Even after the blooming period it is almost certain that insects accidentally carry the blight to the young tips and so are instrumental in causing twig blight also. The key to the whole situation is found in those cases of active blight, (comparatively few), which hold over winter. If they can be found and destroyed, the pear-blight question will be solved, for the reason that without the microbes there can be no blight, no matter how favorable the conditions may be for it; to use a common expression, there will be none left for seed.

TREATMENT FOR PEAR BLIGHT.

The treatment for pear blight may be classed under two general heads: (1) Methods which aim to put the tree in a condition to resist blight or to render it less liable to the disease; and (2) methods for exterminating the microbe itself, which is of first importance, for, if carried out fully, there can be no blight. The methods under the first head must unfortunately be directed more or less to checking the growth of the tree, and therefore are undesirable except in cases where it is thought that the blight will eventually get beyond control in the orchard. Under the head of cultural methods which favor or hinder pear blight, as the case may be, the following are the most important.

Pruning.—Pruning in winter time, or when the tree is dormant, tends to make it grow and form a great deal of new wood, and on that account it favors pear blight. Withholding the pruning knife, therefore, may not otherwise be best for the tree, but it will reduce to some extent its tendency to blight.

Fertilizing.—The better a tree is fed the worse it will fare when attacked by blight. Trees highly manured with barnyard manures and other nitrogenous fertilizers are especially liable to the disease. Overstimulation with fertilizers is to be avoided, especially if the soil is already well supplied.

Cultivation.—The same remarks apply here as in the case of fertilizing. A well-cultivated tree is more inclined to blight than one growing on sod or untilled land, although the latter often do blight badly. Generally good tillage every year is necessary for the full development of the pear and quince trees, and it is more or less so for the apple in many parts of the country; but the

thrift that makes a tree bear good fruit also makes it susceptible to blight. Check the tree by withholding tillage, so that it makes a short growth and bears small fruit, and it will be in better condition to withstand blight than it would were it cultivated. In cases where thrifty orchards are attacked by blight and threatened with destruction, it may often be desirable to plow them once in the spring and harrow soon after the plowing, to plow them only, or to entirely withhold cultivation for a year, mowing the weeds and grass or pasturing with sheep. A good way is to plow the middle of the space between the rows, leaving half the ground untouched.

Irrigation.—In irrigated orchards the grower has the advantage of having control of the water supply. When such orchards are attacked, the proper thing to do is to withhold the water supply or reduce it to the minimum. Only enough should be supplied to keep the leaves green and the wood from shriveling.

Extermination of the blight microbe.—We now come to the only really satisfactory method of controlling pear blight—that is, exterminating the microbe which causes it, by cutting out and burning every particle of blight when the trees are dormant. Not a single case of active blight should be allowed to survive the winter in the orchard or within a half mile or so from it. Every tree of the pome family, including the apple, pear, quince, Siberian crab apple, wild crab apple, the mountain ash, service berry, and all the species of Cratægus, or hawthorns, should be examined for this purpose, the blight being the same in all. The orchardist should not stop short of absolute destruction of every case, for a few overlooked may go a long way toward undoing his work. Cutting out the blight may be done at any time in the winter or spring up to the period when growth begins. The best time, however, is undoubtedly in the fall, when the foliage is still on the trees and the contrast between that on the blighted and that on the healthy limbs is so great that it is an easy matter to find all the blight. It is important to cut out blight whenever it is found, even in the growing season. At that time of the year, however, it can not be hoped to make much headway against the disease, as new cases constantly occur which are not sufficiently developed to be seen when the cutting is done. In orchards where there are only a few trees, and the owner has sufficient time to go over them daily, he will be able to save some which would otherwise be lost. However, when the trees stop forming new wood, the campaign should begin in earnest.

In cutting out the blight, great care must always be taken to cut on the healthy wood well below the lowest point discolored by the disease. It is usually safer to cut at least a foot or more on apparently sound wood, although by carefully studying the case it may not be necessary to go so far below.

An important matter in cutting out the blight is to carry along some disinfecting solution with which to sterilize the knife or other tools used. For this purpose any one of the following solutions may be used: Mercuric chloride, or corrosive sublimate, 1 part to 1,000 parts water; 5 per cent carbolic-acid solution; or, a solution of chloride of lime. The first may be best prepared by purchasing tablets of a definite amount at a drug store. These tablets can be kept in a small bottle, and a pint or quart bottle filled with water and one of the tablets added. Upon concluding work the bottle should be emptied to avoid the danger of poisoning children or unsuspecting persons. By this means the danger of using this deadly poison may be avoided. Carbolic-acid solution may be prepared by simply adding a tablespoonful or more to a bottle of water and shaking it up. The saturated solution, which contains about 5 per cent of carbolic acid, is the proper strength to use. A solution of chloride of lime will answer about the same purpose and is made by adding 20 parts of water to 1 part of the commercial chloride of lime, shaking it up and pouring off the clear liquid. This is only fit for use while fresh. Any of these solutions can be carried by the operator, and a strip of cloth a yard or so in length should be fastened to the clothing, leaving one end hanging free. When cutting into active blight, the ends of the cloth may be kept saturated with the disinfectant and the knife sterilized by wiping before using it on the sound wood. *It is also better to wipe off the wound on the sound wood with the saturated cloth, otherwise there will be danger of leaving the blight germs on the cut surface and merely starting the blight over again.* A knife used to cut into blighting tissue becomes subsequently a veritable inoculating instrument, and should always be sterilized before using on healthy tissues.*

Of course, the greater part of the blight can be taken out the first time the trees are gone over. If this be in midsummer, the

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*Paragraph extracted from article by M. B. Waite, in *Yearbook Department of Agriculture*, 1900.

trees should all be again carefully inspected in the autumn, just before the leaves shed, so as to get every case that can be seen at that time. After this a careful watch should be kept on the trees, and at least one more careful inspection given in spring before the blossoms open. It would doubtless be well to look the trees over several times during the winter to be certain that the blight is completely exterminated. In order to do the inspecting thoroughly it is necessary to go from tree to tree down the row, or in case of large trees to walk up one side of the row and down the other, as in simply walking through the orchard it is impossible to be certain that every case of blight has been cut out.

The above line of treatment will be even more efficacious in keeping unaffected orchards free from the blight. A careful inspection of all pomaceous trees should be made two or three times during the summer and a sharp lookout kept for the first appearance of the blight. It usually takes two or three years for the disease in an orchard to develop into a serious epidemic, but the early removal of the first cases will prevent this and save a great deal of labor later and many valuable trees.

In doing this work it must be remembered that success can be attained only by the most careful and rigid attention to details. Watch and study the trees, and there is no question that the time thus spent will be amply repaid."

LEAF BLIGHT OF PEAR AND QUINCE.

By R. I. Smith.

In connection with the discussion of the true pear blight it seems desirable to mention the leaf blight which is entirely distinct from the former disease. Leaf blight is caused by the fungus *Entomosporium maculatum,* while the true pear blight is caused by a bacteria or germ. Pear twigs attacked by true pear blight show curled and blackened leaves—this feature being very prominent, (see Fig. 1)—but usually the leaves themselves are not killed by the pear blight disease, but die as a necessary consequence, following the death of the twig to which they are attached.

Leaf blight is one of the most serious diseases of the pear, and is also frequently abundant on the quince. The blight first develops soon after the leaves become fully expanded in spring, appearing first as minute reddish spots on the upper surface of the leaves; these spots soon enlarge and penetrate to the lower surface of the leaves. As they increase in size and numbers considerable areas of the leaves may become involved by the fungus itself while the areas in between the spots become greatly weakened. The reddish spots soon change to a deep brown with dark center, finally becoming nearly black. With a magnifying glass minute black dots may be discovered in the center of the spots, these dots being the fruit or spores of the fungus. When leaves are badly affected it results in severe shedding, so that the pear trees often appear as bare in mid-summer as they normally would in winter. Almost complete defoliation is frequently encountered in the pear orchards in South Georgia. This of course results in great injury to the trees which are prevented from storing up materials of growth necessary for their continued health and development.

Unfortunately leaf blight is by no means confined to the leaves but appears on both twigs and fruit. The former are attacked much the same as the leaves. The fruit first becomes covered with reddish pimples, soon changing to nearly black, while the diseased tissue begins to crack in such a manner as to ruin the fruit. Even when pears attain full size, the cracking may be so severe that the fruit will be unsalable.

Hot, dry weather seems to be favorable to an increase of pear leaf blight, though the disease is liable to develop almost every season. When young tender leaves are attacked the result is that

they become curled, due to a contraction of the diseased areas. Full grown leaves usually retain their shape even when completely covered by black spots.

One result of severe defoliation is that pear trees are forced into a second growth if weather conditions are at all favorable, and frequently the second growth of leaves are attacked and destroyed by the fungus. This lack of foliage in middle and late summer is almost sure to induce many fruit buds to open late in the fall, thereby decreasing the chances for a crop the following year. Pear orchards in South Georgia are sometimes white with bloom during the latter part of October, and not infrequently small fruit is developed.

Remedy for the Leaf Blight.

Experiments have shown that the leaf blight is readily controlled by the proper use of Bordeaux mixture. Early spraying, before the leaf buds expand, is not necessary in controlling this disease, though for many other troubles the early spraying is advisable. One thorough spraying with Bordeaux as soon as the trees are in full foliage—about two to four weeks after the blossoms fall, according to M. B. Waite,* and a second application two weeks later, is usually sufficient to control the disease for the season. On rapidly growing nursery stock it is often necessary to spray five and six times to keep the new foliage covered as fast as it appears. For adult pear trees Bordeaux mixture at the rate of 4 pounds of blue stone (copper sulphate), to 6 pounds lime in 50 gallons of water should be the strength employed. For nursery stock it would be well to use a weaker strength.

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* *Yearbook, Department of Agriculture*, 1900, p. 889.

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INSECTICIDES AND FUNGICIDES.

SPRAY CALENDAR.

By R. I. SMITH, State Entomologist.

CAPITOL BUILDING

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SPRAYING TO PREVENT OR SUPPRESS INSECTS AND PLANT DISEASES.

Introduction.

The wonderful increase in recent years in the use of insecticides and fungicides for the control of insects and diseases affecting fruit trees and plants of all varieties, cannot better be appreciated than by observing the many materials now on the market for these purposes. Some of the manufactured products advertised as sure insect destroyers, and preventives or cures for fungous diseases, possess real merit, and may be accepted by fruit-growers and others who need to spray trees or plants. Still it is true that practically all insects and fungous diseases, which submit to treatment, may be controlled by some home-made mixture, which is both cheap and reliable. The question of simplicity in preparation may affect the above statement; for instance, Bowker's Disparene is simply arsenate of lead which can be made at home much cheaper than the manufacturers can afford to sell the same material. Even so, many people prefer to pay the extra cost to save the trouble of purchasing separately the necessary ingredients, and making the combination themselves. The manufacturers product needs only to be diluted with cold water when it becomes ready to use without further preparation.

Many patent preparations for killing the San Jose scale have come out in recent years. Some have proved beneficial to a certain extent while others have turned out to be absolutely worthless. A few recent manufactured products have been used in some states against the San Jose scale and given results equal to those obtained by spraying with Lime-sulphur-salt wash.

The fact remains, however, that nothing has been used in Georgia (to the writer's knowledge) which is as cheap, even if effective, against scale, as the standard Lime-sulphur wash.

The writer does not wish to be understood as standing out against patent insecticides, provided they possess true merit, but he does wish to impress the reader with the idea that the home-made insecticides and fungicides are usually cheaper and often more effective than the so-called patent preparations.

It will be the purpose of this bulletin to mention all the standard insecticides and fungicides of present importance, but not to give space to—at least more than a mere mention—those preparations which are seldom if ever used in ordinary practice.

There is at present in Georgia a need of more knowledge concerning the preparation of the common spray solutions. Bordeaux mixture for instance is now made in various ways and by varying formulae, while in fact *proper* Bordeaux is made by one certain process only, and the formula adjusted to suit the nature of the plant to which it will be applied.

The spray calendar has been given careful attention and while by no means perfect, it will show about the treatment required for control of insects and fungous diseases of certain plants.

Reasons for Spraying.

Under this head very little need be said. The necessity for spraying to control or prevent the various insects and plant diseases, is seen on every side. The San Jose scale in Georgia six or seven years ago gave promise of destroying the peach industry. The use of certain spray solutions has now demonstrated without doubt that the pest can be largely controlled. Even now in a few localities where fruit growers have been slow to adopt the improved spraying methods, the San Jose scale is considered almost sure death to the infested trees. Fortunately there are not many such places in Georgia. There should not, and would not, be any such if the remedial methods now recommended would be adopted by all fruit growers.

Spraying operations for the destruction of insects, and sprayings directed against fungous diseases are often quite different. Insects must in most cases be killed by spraying or some other process when they first appear, while to control certain fungous diseases the spraying must be done before the true disease is

apparent. The cause of the disease—as described farther on—must of course be actually present, or at least close at hand; hence spraying to control fungi is often a real preventive and amounts to an insurance. It may sometimes be done when not necessary, that is, when certain unforeseen weather conditions perhaps prevent the expected disease from developing. This is unavoidable, however, for to wait and see if the disease would appear might in certain cases prove disastrous to the tree or plant in question.

As stated above, most insects may be fought when they appear. In certain cases, even with insects, it is advisable to provide some insurance against their attack on certain crops, such as cucumbers and cantaloupes, which may be sprayed with Bordeaux mixture as a repellent against cucumber beetles and flea beetles for example.

It ought to be understood that there should always be a reason for spraying before such work is undertaken. Fungous diseases, such as apple scab, peach leaf curl, and pear leaf blight, may be expected to appear this year if they were present last year. Fungicides must therefore be applied as a preventive.

Insects like plant lice, caterpillars and scale insects may be destroyed by spraying after they have appeared; but with the apple codling moth, however, it is different. Poison spray must be applied just after the blossoms fall, even though the apple grower has not seen the insect which he aims to kill.

It is evident therefore that no rules for spraying can be laid down, which do not depend on the fruit-grower or farmer to determine what pests he has to combat. Each crop must be watched and studied to determine what spraying is necessary. Wherever it is found that some fungous disease is bad one year it serves to show what must be done to prevent a recurrence of the trouble.

A study of bulletins dealing with insects and plant diseases, and the accounts of all such in the better horticultural papers, will serve to teach the uninitiated how to look for the troubles—and hence the reason—why spraying is necessary.

Insects of Two Classes.

In order to understand the reason why a certain insecticide, kerosene emulsion for instance, is used to destroy plant lice, and

why Paris green is recommended against the cabbage worm, it is necessary to note the difference in the two insects.

Kerosene emulsion is a substance that will kill a soft-bodied insect by contact, and the adult plant lice can be killed by spraying only in this way. The reason for this is that plant lice feed by sucking the plant juices by means of a slender beak. A poison such as Paris green is not effective against this insect, but would be effective against the cabbage worm, as it feeds by actually devouring portions of the cabbage plant.

Plant lice may serve as an example of the class of insects that derive nourishment by puncturing and sucking juices from the plants attacked. Insects of this class can only be reached by some insecticide which has a penetrating, corrosive, caustic, or suffocating property. The numerous scale insects are in this class, and several garden insects such as, squash bug, Harlequin cabbage bug, and tarnished plant bug, also feed in a like manner.

Insects which devour the foliage, or any part of the plants, unless very soft bodied like young cabbage bugs and rose slugs, are not generally fought with contact poisons. These biting insects are destroyed by some one of the internal poisons, many of which are composed of a preparation containing arsenic in some form.

Use of Insecticides.

An insecticide, broadly speaking, is any substance that will kill insects in one way or another. Under the short discussion of the two classes of insects we have seen that there are the biting and the sucking insects.

Insecticides are divided into two classes, and sometimes a third. The two main divisions are: Insecticides which act as internal poisons for biting insects, and those which kill by contact, for sucking insects. The third division which may be mentioned is one having both properties, such as Hellebore, which is generally used as an internal poison, but also kills some soft-bodied insects by contact.

The basis of nearly all internal poisons is white arsenic, prepared in many ways which renders it fairly safe to use on growing plants without danger of burning the foliage. White arsenic alone contains a caustic property quite injurious to foliage, but when made into *pure* Paris green it is rendered insoluble and can then be applied to plants without any injurious effects.

Insecticides, generally speaking, are not effective against fungous diseases. There is a notable exception, however, to this rule, and one that every one, fruit growers particularly, should understand. This exception is the Lime-Sulphur-Salt wash, used against the San Jose scale. It has been proven in Georgia that this wash applied to peach trees in January or February will prevent the peach leaf curl disease as well as an application of Bordeaux mixture. Further experiments may show that leaf curl may be prevented by spraying in early winter, the same as is sometimes practiced against scale. The Lime-Sulphur-Salt wash acts on the San Jose scale, and all scale insects mainly by its corrosive effect, and partly by a direct or immediate penetrating action. The combination of lime and sulphur formed by boiling the two together, makes a mixture having also a high fungicidal value. Hence peach trees in North or Middle Georgia infested with San Jose scale, and liable also to an attack of leaf curl, may be protected by applying simply the Lime-Sulphur-Salt wash at the proper time. Another example of a spray solution acting a double purpose is seen in Bordeaux mixture, which is often applied to plants, as already mentioned, as a repellent for certain insects.

The above remarks are intended to show how great is the advantage of knowing the true value of spraying solutions and the different uses to which they may be applied. Insecticides applied without thought of the purpose for which they are intended are often wasted; in fact, worse than wasted.

In short, the person who employs insecticides must first of all determine if the insect to be destroyed is a biting or sucking form. Then he must select the treatment best adapted to the case.

Fungi and Uses of Fungicides.

A fungicide is any substance that will kill or prevent the growth of fungi. Not all fungicides can be used with safety on growing trees or plants. A fungicide, then, to be of value, must be one that can be used to destroy or prevent the growth of fungi without at the same time injuring the host plant.

A brief explanation of a fungus may be of value to help explain the use of fungicides. The word fungus is applied to the low forms of plant life, like the toad-stools, mushrooms, molds, mildews, rusts, smuts, and similar organisms. We are told by

eminent botanists that a fungous growth is a plant, as much as the oak tree, cotton plant, or other common vegetation. The plural of the word fungus is fungi, (pronounced *funji*). Fungi assume a vast number of forms, some being found on dead and decaying vegetation, and some on healthy growing trees and plants. It is difficult to realize that all the forms of lower plant life are so closely related; but the only ones with which we are concerned are those occurring on plants, and by their presence causing some form of disease.

Each fungus has a definite form of growth, and in a broad sense this growth must be understood, before the matter of fungicides can be comprehended. Most of the principal disease-producing fungi live and develop mainly in the tissue of the leaves, stems, fruit or other parts of the host plant. For instance, peach leaf curl attacks leaves and sometimes stems, and brown rot attacks both flowers and fruit. Such fungi grow by means of microscopic threads, called *mycelium*, these being found in the tissue of the leaf or fruit; later the fruiting form of the fungus, known as spores, appear. In many cases these spores are carried over winter on the tree, as in case of leaf curl. These spores are so minute that they cannot be seen except with the aid of a microscope, but we know that they are present and may be destroyed by the application of some fungicide, preferably during February.

The basis of many fungicides is copper in the form of Copper Sulphate (bluestone) most commonly used as Bordeaux mixture. Mention was made under insecticides of the discovery that Lime-Sulphur-Salt wash might be used in place of Bordeaux in winter, and that discovery has been of great importance, as it often saves making two sprayings, one following the other immediately.

In the following pages the fungicides of particular value will be mentioned, and especial stress will be placed on the combination of fungicides and insecticides wherever that is practicable.

Thorough Spraying Necessary.

Any one who has practiced spraying knows full well the necessity of thorough work. Particularly is this true of fungicides. The spores of fungi may be present on any portion and in every crevice of the bark of the tree from the ground up. A fungicide applied to destroy these spores must therefore touch all exposed

places, and if applied as a preventive it must likewise cover all portions of the plants or trees, as the spores which start the disease may alight on an unsprayed spot and develop without hindrance.

Insecticides which kill by contact need to be applied equally well, as it is only by coming in contact with an insect that these materials are effective. When spraying to destroy the San Jose scale every spot on the infested trees must be touched else many insects will escape the treatment. Poison sprays applied to fruits and foliage may sometimes be found by insects even though the work may not have been done thoroughly. Caterpillars moving about over a tree may chance to eat the poisoned foliage, but at the same time they are free to seek out the unsprayed places, and some insects will do that. Hence for all spraying the work must be done thoroughly. All spray solutions should be applied with a good force spray pump and spray nozzle. This allows for applying materials with considerable force and still getting them on the trees in the form of a fine mist. If any one attempts to spray by simply spattering the trees or plants they may expect to have poor results. Whenever it pays to spray at all it pays to spray thoroughly.

Selection of Spray Pump and Accessories.

The question of selecting a suitable spray pump for general or special uses must rest mainly with the individual. It is impossible for one to say which pump is the "very best" on the market, for the very reason that all pumps possess some good qualities—but some more than others.

The first question must be, what kind of a pump do I need? That will depend on the nature of the work to be done; whether it is desired for spraying small trees or large trees; whether it will be used for oil emulsion or for lime-sulphur wash. Good durable bucket pumps equipped with a long hose and a good nozzle might be made to answer for spraying large trees, but they would not be found economical. Neither would it pay to purchase a large wagon tank pump, or power sprayer when only a little work is to be done. Bucket pumps, knapsack pumps, compressed-air sprayers, barrel pumps and power sprayers, all have their place and the selection must rest with the one who has to use the pump.

Regarding the points of a good pump we will take for example a barrel pump, the commonest and probably the most widely used of all pumps in Georgia, and briefly mention the different parts.

The Material:—A pump should be made of material that will not easily corrode or rust from contact with the various spray solutions. Brass appears to be the best metal. When lime-sulphur wash or Bordeaux mixture is used pumps with brass working parts should be insisted upon by the purchaser. Any pump with all the working parts brass and much of the body of the pump of the same material will be the best for all purposes.

Packing and Valves:—Pumps with solid plungers are far superior to those that have to be packed by winding with candle wicking or some special preparation. The best style of packing is one that can be put in place without removing the plunger. This in reality is an "outside" pack. In the large horizontal pumps two cylinders are present, each having a powerful plunger with outside pack. In practice it is found that these large pumps supply power with less effort than the smaller barrel pumps.

The valves should all be of brass and so arranged that the operator can easily remove and clean them when necessary. Perfect fitting valves are an absolute necessity in a powerful pump. The matter of an air-chamber naturally arises when speaking of valves, and this is an important feature about a pump. The air-chamber should have sufficient capacity to insure a steady pressure that will not fall off the minute the pump handle stops moving. A good pump will hold a heavy pressure for several minutes after the pump is stopped. Poor packing often results in poor pressure, and should always be remedied without delay.

Agitators:—No pump is complete without a good agitator Most barrel pumps have the agitator attached to the handle. In wagon tanks, where suction pumps are used, a separate agitator should always be supplied. Some failures in spraying could be traced to not having the spray mixture thoroughly mixed.

General Structure of Pump:—The claim has often been made that the recent makes of pumps are superior to some old makes because the main part of the pump is low down, mainly in the barrel, and hence is not in the way. Such pumps do certainly have an advantage in some ways but at the same time they are not so accessible, and hence not so easily adjusted and cleaned.

It is important that a pump should be easy to clean and adjust, and prospective buyers will do well to remember this point.

The change from barrel outfits to wagon tanks has resulted in enormous saving to many large orchardists, and any one who has much spraying to do should investigate the matter of wagon tanks and also the matter of power sprayers.

Hose:—The matter of good hose is important. Long hose, allowing a chance to work at a distance from the spray tank, results in much convenience and saving of time. The mistake of trying to use too short hose is often made. A pump for spraying orchard trees should never be equipped with less than twenty feet of hose—with extension rod on the end—and 25 or 30 feet of hose is often used with profit.

The Extension Rod:—Is necessary for good work. A rod may vary from 6 to 10 feet but the former length is usually sufficient. They can be made from one-fourth inch gas piping and can be cut by any blacksmith who has a device for cutting threads. Such rods are about as serviceable and cheaper than the brass rods with bamboo covering.

Stop-Cocks:—These are necessary to avoid wasting material when moving from tree to tree. Also when the nozzle gets clogged the stop-cock comes in handy. It should always be used behind the extension rod on the end of the hose, where it is easily operated by the spray-man.

Nozzles:—The selection of nozzles is a matter of taste, but should depend much on the kind of spray material used. With oil emulsions, Bordeaux and arsenical sprays a fine nozzle, one throwing a mist, is needed. For spraying with lime-sulphur wash the finest nozzles are not desirable, as they do not allow of putting the mixture on with sufficient force or with sufficient rapidity. A nozzle should be so constructed that it can be easily taken apart and cleaned. One that leaks after a little use should be rejected.

Care of Pumps and Accessories.

Spray pumps, hose and nozzles will last several years when given proper care. This consists of cleaning out all parts each night after spraying. Hose should be hung up so that the water will run out quickly. If all working parts of the pump and nozzle are cleaned each night much vexatious stoppage and loss of

time will be avoided. Such treatment prolongs the life of the pump, and saves time and money to the owner.

When through using pumps and nozzles all metal parts should be scraped clean and greased to prevent rusting. Machinery of this kind is too valuable to neglect, and besides a pump should always be ready to use at short notice, and unless given proper care when through using, it will always be found out of order when wanted for some immediate work.

MATERIALS AND DIRECTIONS FOR PREPARING INSECTICIDES AND FUNGICIDES.

I. Paris Green. (*As a liquid spray.*)

Paris green is a common form of internal poison in which arsenic is the essential element. A good Paris green must contain about 55% of arsenious acid, and in some states the law requires this standard, or very near it. In its pure form it is insoluble in water and could therefore be used on plants without burning foliage. The commercial forms now on the market, however, are not absolutely pure, so that lime must always be used with Paris green and water. Lime combines with the water soluble arsenic, of which there is often from 4 to 6 per cent present. In practice 2-3 pounds of lime are used with every pound of Paris green for making a liquid spray.

Plants vary greatly in their power of resisting the burning action of impure Paris green. Potatoes are among the most resistant, and apple also is not easily affected. Peach foliage is very susceptible, and hence only a small proportion of poison can be employed. For potatoes to control the potato beetle Paris green may be used, 1 pound to 100 gallons of water; on apple use 1 pound to 125 gallons of water; on peach use *only* 1 pound to 200-250 gallons of water, always remembering that lime is necessary.

Paris Green	1	pound
Lime (fresh unslacked)	2 to 3	pounds
Water	200 to 250	gallons

The above shows how the poison should be used. To prepare: First mix the Paris green into a paste with a small amount of water; then dilute to about a bucketful. Slake the lime with a small amount of warm water and add to the Paris green mixture.

The mixture is then ready to dilute to the required strength. By this process there will be no danger of the Paris green forming in lumps, which would happen if the dry powder were added to a large bulk of water. This poison is purchased in the form of a finely divided, heavy powder composed of minute crystals. These crystals sink rapidly in water, necessitating constant stirring of the mixture while spraying. It should be understood that water acts only as a carrier for Paris green. When spraying plants the mixture must be applied in a fine mist, so that when the water evaporates the poison will be left in a very thin coating over the entire plant. The lime helps to hold this poison and prevents its being easily washed off.

Bordeaux mixture may be used as a carrier, and will hold the poison better than the lime alone.

II. Paris Green. (*In dry form.*)

Paris green may be used dry by mixing with from 10 to 50 parts of flour, land plaster, air-slaked lime, ashes or similar material. If not almost pure the water soluble arsenic may be dissolved by dews and light rains, and some burning of foliage may result. Some forms of dust spraying machines, for applying Paris green pure or with very little dilution, are on the market, but they must be used with great care.

TEST FOR ADULTERATION OF PARIS GREEN.

Place a spoonful of Paris green in a small glass tube or slender bottle. On this pour a small quantity of ammonia. Pure Paris green will completely dissolve. Most adulterants will settle to the bottom. This test will not detect presence of water soluble arsenic.

III. Green Arsenoid.

This is a cheaper substitute for Paris green, and is practically the same substance, except that it is not crystalized. Green arsenoid is lighter than Paris green, requiring less stirring and may be used in the same proportion. It should never be used without lime, however, as it frequently contains water soluble arsenic. This poison usually sells for considerably less than Paris green, and is valuable for that reason, and because it will remain in suspension in water more readily than Paris green.

IV. London Purple.

This is another cheap form of arsenical poison, and one that has in past years been used quite generally. The results from its use have not been entirely satisfactory, as the commercial product is quite variable, often containing enough soluble arsenic to seriously injure foliage. Like Green arsenoid it has the advantage of being lighter than Paris green, hence more readily kept in suspension. It has also the advantage of being cheap, and could well be employed where there would be little danger of its injuring plant foliage. London purple is used in the same way as Paris green with Bordeaux mixture or in water with lime.

V. Arsenite of Lime.

Stock Solution	White arsenic............	1 pound
	Lime (fresh unslaked)....	2 pounds
	Water..................	1 gallon

To prepare, boil the two ingredients together for 45 minutes; after boiling add water to make up for evaporation and keep this stock solution in a tight vessel. Use 1 quart of this stock solution to 1 barrel of water.

When prepared with good lime and properly boiled this arsenical poison can be used safely, as directed, on most plants. Its advantages are that it is very cheap, costing about $\frac{1}{3}$ as much as Paris green. The precipitate is quite light, requiring very little stirring. This form of poison deserves notice wherever cheapness is required.

VI. Arsenate of Lead.

Acetate of Lead (*Sugar of Lead*).....	11 oz.
Arsenate of Soda	4 oz.
Water	50 gallons

To prepare, dissolve the acetate of lead in 1 gallon of water in one vessel, and dissolve the arsenate of soda in 2 quarts of water in another vessel. It is best to use wooden buckets. When dissolved completely pour the arsenate solution into the lead solution. As they unite a fine white precipitate is formed which remains in suspension for a long time. This mixture is added to 50 gallons of water and stirred and is then ready for use.

The precipitate is arsenate of lead. This will remain in suspension longer than any of the arsenicals mentioned above; besides having this advantage it is in such fine particles that it adheres to foliage better and longer than most spray mixtures. Trees sprayed in April will often have an appreciable amount of poison on the leaves in September.

Arsenate of lead costs a little more than Paris green as the actual per cent of arsenic is low, hence more pounds must be used in a given amount of water. Fifty gallons of mixture made as above should not cost over ten or twelve cents. At this price it is not much more costly than Paris green when it is considered that the former poison is not readily washed off by rains.

A chemist of the Massachusetts Gypsy moth commission discovered the value of this poison in 1892. It is now manufactured and sold by the Bowker Insecticide Co., Boston, Mass., under the brand name, "Disparene" and by the Merrimac Chemical Co., Boston, Mass., under the name "Swift's Arsenate of Lead." Disparene may safely be used on all but the most tender foliage at 2-3 pounds to 50 gallons of water. It has advantages of being easy to mix (mixes in cold water), requires practically no stirring, adheres well, its white color shows what has been sprayed and its use is attended with practically no danger of burning foliage.

VII. Lime-Sulphur-Salt Wash.

Lime (fresh unslaked)	20 pounds
Sulphur	16 pounds
Salt	10 pounds
Water (to make)	50 gallons

To prepare mix sulphur into a paste and add to about 15 gallons of boiling hot water in kettle, or boiling tank if steam is used. Add the lime and stir occasionally while lime is slaking. Last of all add the salt and continue to boil the mixture rapidly for 45 minutes or longer if necessary to secure the proper color. After boiling sufficiently the solution when stirred should be a dirty greenish-yellow color. *The bright yellow color of the sulphur should not be apparent.* If it is, the mixture needs more boiling. After the concentrated mixture is boiled dilute with warm water to 50 gallons, and use while warm. (*For more complete directions for making and applying this wash see Bulletin No.* 14 *of the Georgia State Board of Entomology.*)

Lime-sulphur-salt wash is the principal remedy for the San Jose scale in Georgia. It is intended for use only when trees are dormant. It kills scale by contact, hence must be applied thoroughly. As a fungicide this wash is equal to Bordeaux, but its use as such is of course limited to the winter season. The Lime-sulphur-salt wash was first used against the San Jose scale in California. It has now proven thoroughly effective in Georgia, after several years of successful application.

Many people think that the salt in the above formula is necessary but our experiments have not shown this to be true. We have found the following mixture just as effective as the one mentioned above.

VIII. Lime and Sulphur Wash.

Lime	20 pounds
Sulphur	16 pounds
Water (to make)	50 gallons

Directions for preparing same as No. VII. The writer thinks that this wash is really preferable to Lime-sulphur-salt wash on account of the fact that the salt probably causes spraying machinery, steam pipes, boilers, etc., to rust much more readily than they would in the absence of salt.

Another form of Lime-sulphur wash which can be made without much heat is as follows:

IX. Lime-Sulphur-Soda Wash.

Lime	16 pounds
Sulphur	8 pounds
Commercial caustic soda	8 pounds
Water	50 gallons

Mix the sulphur into a thick paste with a small amount of BOILING HOT water. Then add the caustic soda slowly (do not dissolve the soda in water) keeping the mixture thoroughly stirred. A brick-red color will appear almost at once. Continue the addition of the soda, and continue stirring, adding small amounts of hot water as may be necessary to prevent the mixture getting too thick. The soda should dissolve all of the sulphur in a few minutes, producing a clear deep red liquid. Unless the liquid is entirely clear, with no particles of undis-

solved sulphur remaining, the mixture must be heated until all sulphur is dissolved. It is ABSOLUTELY IMPERATIVE THAT ALL SULPHUR BE DISSOLVED AND A CLEAR LIQUID OBTAINED BEFORE THE LIME IS ADDED. To the clear liquid described, add the stone lime, previously weighed out, and while it is slaking keep well stirred. The completed preparation will have the familiar greenish-yellow color characteristic of the Lime-Sulphur preparations. Dilute with cold water to the desired point and spray at once.

This wash is too expensive for general use in large or commercial orchards, but is well adapted to those cases where but a few trees are treated, as is often the case upon city or town premises. The effect upon the scale by this wash is not as good as the regular Lime-Sulphur wash, and in the case of badly infested trees, therefore, two sprayings should always be given, the first in December and the second in February before the buds open.

X. Kerosene Emulsion.

Stock Solution	Hard soap (soft soap 1 quart)	½ pound
	Water	1 gallon
	Kerosene	2 gallons

Place a kettle containing one gallon of water over the fire and in it dissolve the soap. The water should be boiling hot. Remove this solution from the fire and add 2 gallons of kerosene, after which the mixture must be agitated violently for about ten minutes. As the kerosene and soap solution combine a smooth creamy emulsion will result, the bulk will increase nearly one-half, and when properly mixed the resulting emulsion will remain without separating for several weeks. This emulsion is most easily prepared by using a small force pump having a direct discharge and throwing a one-eighth inch stream, pumping the solution back into itself with considerable force. After ten minutes pumping the emulsion, made this way, will be perfect. Soft water should be used for making emulsions, but if such water is not readily obtainable, hard water may be broken by adding a little lye, and may then be used with safety.

This stock solution of kerosene emulsion may be diluted with water to any required strength, but care should be taken to have it thoroughly mixed before using. Stock solutions should be mixed

first with a small amount of water, and diluted to required strength.

For convenient reference the proper amounts of water used in diluting the stock solution for certain strengths are given herewith:

For 5 per cent. emulsion dilute with 37 gallons of water.
For 10 per cent. emulsion dilute with 17 gallons of water.
For 15 per cent. emulsion dilute with 10⅓ gallons of water.
For 20 per cent. emulsion dilute with 7 gallons of water.

This is another contact insecticide valuable for destroying plant lice, San Jose scale and other scale insects. It is also used to destroy Woolly Aphis on the roots of apple trees. 15% emulsion is employed against plant lice, but for San Jose scale the 20% strength is necessary to kill the nearly mature insects. For winter use this emulsion is not recommended in Georgia, the lime-sulphur wash having taken its place.

Kerosene emulsion must be carefully prepared, and when diluted with water the mixture should be violently agitated, to form a homogeneous mass. Bright sunshiny days should be selected for spraying in order that the kerosene may evaporate rapidly; otherwise some burning of foliage may result.

XI. Tobacco. (*As a liquid spray.*)

Tobacco stems	3 pounds
Water	5 gallons

Boil for about two hours, adding water to make up for evaporation. Apply without diluting. Valuable for destroying plant lice on all crops. It also acts as a repellent against certain insects such as the potato flea-beetle, striped cucumber beetle and other enemies of the cucumber family. Some good forms of tobacco extract, containing a high per cent of nicotine (the essential element in tobacco spray) are now on the market, and as they are in liquid form ready to mix with water, they are preferred by some people. Used extensively in greenhouses.

(*As dry powder.*)

Tobacco is also used in dry form as a fine powder. For the underground form of the woolly aphis tobacco dust, made by grinding tobacco stems, is recommended to be placed in the soil

around the infested trees. For young trees, two to five years old, use about three to five pounds of dust. For larger trees use a proportionately greater amount. This dust is applied by removing two or three inches of the top soil in a circle two to four feet in diameter; sprinkle the dust in this opening and replace soil. Tobacco stems will not take the place of dust as their action is too slow. Tobacco is a good fertilizer as well as insecticide, so that its action is two-fold, giving it an advantage over other insecticides for certain uses.

XII. Whale Oil Soap.

This is another contact insecticide useful for spraying plants infested with plant lice and scale insects. Whale oil soap is made from refuse fish oil, saponified with potash or soda. The potash soaps are preferable to the soda soaps, as the former dissolve more easily and do not tend to solidify after being diluted with water. At one time this form of soap was used extensively during winter against the San Jose scale, at 2 pounds to 1 gallon of water. Now the lime-sulphur wash is preferable on account of its costing less and really giving more satisfactory results. For destroying plant lice this soap should be used at the rate of 1 pound in 2 to 5 gallons of water.

Housewives who have plants infested with lice, scale or other insects will find it beneficial to wash such plants frequently with a solution of this or some similar soap, using 1 pound in 5 gallons of water.

OTHER SOAPS.

Several kinds of soap are on the market, such as tobacco soap, carbolic soap, fir-tree oil soap, naphtha soap, tar soap, and others, all of which find a limited range of usefulness. They are nearly all too expensive for general field use, but are considerably used in greenhouses, or for small gardens. One new brand, namely, "Tak-a-nap Soap" a naphthaline product, deserves mention as it is valuable for making emulsions, and also has some direct insecticidal value. It is sold at about the same price as potash whale oil soap.

XIII. Adhesive Resin Wash.

For some plants with very smooth foliage, difficulty is often experienced in making poison mixtures adhere. To overcome this trouble the following is suggested:

Stock Solution	Pulverized resin	5 pounds
	Concentrated lye	1 pound
	Fish oil	1 pint
	Water	5 gallons

This solution is prepared by boiling. To prepare: Place the oil and resin in one gallon of water and boil until the resin is thoroughly softened. Next dissolve the lye in a separate vessel and add slowly to the resin mixture, stirring constantly until well mixed. Then add four gallons of hot water and continue the boiling until the resulting solution will mix readily with cold water. Water may have to be added to make up for evaporation.

Directions for Using.

Resin mixture (stock solution)	1 gallon
Water	16 gallons
Milk of lime	3 gallons
Paris green or green arsenoid	¼ pound

Milk of lime is simply fresh slaked stone lime, containing about 1 pound of lime in 1 gallon of water.

To prepare for use add water to the stock solution, and mix thoroughly; then add the milk of lime and last of all the arsenical poison. Do not change the order of mixing or a heavy precipitate will form that will clog up the spray pump and nozzles.

The stock solution may be kept on hand for instant use, but the diluted mixture must be made fresh each time. A mixture of this nature will stick to the smoothest foliage. It is very valuable for use on young eabbage plants.

XIV. Pyrethrum.

Pyrethrum, also known as Buhach, Dalmation Insect Powder, and Persian Insect Powder, is a powder made by grinding the flowers of a plant of the genus *Pyrethrum*. It contains an essential oil, poisonous to most insects, but harmless to higher animals. The oil acts on insects only when in contact with them, in the same manner as kerosene emulsion or similar contact poisons. The oil in pyrethrum is very volatile, that is, it evaporates rapidly when exposed to the air; hence pyrethrum to be of value must be confined in air-tight receptacles until used. Grocers often keep this powder in open boxes or loose drawers. Such pyrethrum is absolutely worthless.

In dry form, undiluted, pyrethrum is useful—when fresh—against lice, thrips, etc., on roses and tender plants, and may be applied with perfect safety. It is used in the same way, or diluted with flour, to destroy cabbage worms when the heads are nearly grown. It can be used with safety on vegetables that are ready to be used as food. Must be applied at least every two days until insects are destroyed.

In solution pyrethrum is used 1 ounce in 3 gallons of water. In this form it is useful on delicate plants, as it will not injure the foliage or leave an appreciable stain.

XV. Hellebore.

Is made from the roots of a plant and acts much like pyrethrum. Hellebore will act as an internal poison, as well as a contact poison, and may be used in the same proportions as pyrethrum. It cannot be said that Hellebore is a very active poison, hence its use is rather limited.

XVI. Poisoned Bait.

Cutworms may often be poisoned early in spring when land is first prepared, and most vegetation dead, by a poison bran mash made as follows:

Paris Green or White Arsenic	1 pound
Bran	40 pounds
Molasses or thick sugar water	2 quarts
Water, enough to make a soft mash or dough.	

This mash may be placed on land in little heaps just before nightfall; or a spoonful placed at the base of each plant, such as tomato or cabbage.

Another plan is to spray a small piece of succulent clover with Paris green, 1 pound to 25 gallons of water, cut the clover, and spread while fresh on land just before night. The land must be free from other vegetation, so that the cutworms will be forced to eat the poisoned bait. Some authorities state that bran is so well liked by cutworms that it will be eaten when other food is plentiful. In practice it will be found best to poison cutworms and similar pests when their favorite food is not available.

XVII. Bordeaux Mixture.

This is the form of fungicide most widely used, and at the present time almost as many formulas are recommended as there are writers about its use. Some writers recommend the "Normal Bordeaux," in which 6 pounds of copper sulphate and 4 pounds of lime are used in 45 gallons of water. Others reverse the amount, using an excess of lime.

The two necessary ingredients in Bordeaux are Copper Sulphate (bluestone) and fresh lime. Nothing else is necessary. When these ingredients—each in solution—come together, an insoluble precipitate is formed, which is really an insoluble substance, the water of the mixture acting only as a carrier. If this precipitate is allowed to settle and then separated from the water and dried, it will possess the same fungicidal property as when in the liquid form. If some means were at hand to apply the dry Bordeaux in as even a manner as the liquid it would serve the same purpose.

Proper Bordeaux is made by pouring together *dilute* solutions of bluestone and lime. The amounts of each ingredient in the solutions may vary widely and still secure good Bordeaux, but the solutions must always be in dilute form before mixing. Otherwise the precipitate formed will be heavy and sink rapidly in the resulting mixture.

For a STANDARD Bordeaux to use on all perfectly dormant plants we recommend the following:

Copper sulphate (bluestone)*	5 pounds
Lime (fresh unslaked)	6 pounds
Water	50 gallons

Even greater amounts of bluestone and lime than in the above may often be used with safety, but such strength is seldom required. On plants and trees in foliage the amount of bluestone must be reduced in proportion to the resistant power of the plant. Potatoes will stand a strength like the above. Apple and pear foliage will bear 4 pounds of bluestone with 6 pounds of lime, but for peach and plum and other tender plants, such as tomato, the amount of bluestone should be reduced to 3 pounds and the lime increased to 9 pounds. Even then under certain weather conditions peach foliage will occasionally be injured. Bordeaux

*See paragraph headed "XXI. Copperas."

Fig. 1. Making Bordeaux mixture. Pouring the Lime milk and Bluestone solutions together. (From U. S. D. A., Farmer's Bull. No. 38.)

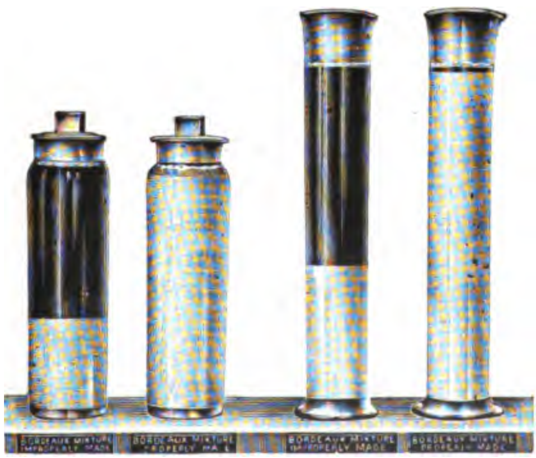

Fig. 2. Improperly and properly made Bordeaux after standing one hour. The properly made Bordeaux is just commencing to settle. (From U. S. D. A., Farmer's Bull. No. 38.)

mixture will injure foliage unless good lime is used, and the amount of lime must nearly always equal if not exceed the amount of bluestone. In practice it will always be seen that we recommend using an excess of lime. No matter what formula of Bordeaux is used the following directions should always be followed:

Directions:—Slake the lime with enough warm or hot water to reduce it to the consistency of cream and dilute to 25 gallons. Dissolve the bluestone in 25 gallons of water by suspending the crystals in a coarse sack a few inches below the surface of the water. The bluestone will dissolve most rapidly if kept in motion; or a small amount of warm water may be used in which to dissolve the bluestone, and the solution then diluted to 25 gallons. Bluestone solution should always be cold when the Bordeaux is made. Now take a third barrel and pour the two solutions together by dipping up a pailful of each and allowing the streams of the two to mingle in mid-air as they are poured into the barrel. After thorough stirring the Bordeaux will be ready for use. It should be thoroughly strained to prevent any foreign matter entering the spray pump to clog the nozzles.

Bordeaux mixture should always be made fresh as the precipitate settles in a few hours, and after once getting thoroughly settled it will not again remain easily in suspension. Good fresh Bordeaux should not require much stirring, though it is best to have the spray pump provided with a good agitator.

Stock solutions of Copper Sulphate and of lime water may be kept an indefinite length of time. A good method to follow in making stock solutions for Bordeaux mixture is to dissolve 50 pounds of bluestone in 25 gallons of water, or in some definite amount. Then by dipping out 2 gallons of the solution and diluting it to 25 gallons, you will have 25 gallons of bluestone solution containing just 4 pounds of bluestone. The lime may be slaked and kept in a certain amount of water and measured out in the same manner. A good way to insure having fresh lime on hand all summer when lime in barrels is liable to air-slake is to slake the lime and keep it as suggested for stock solution. As long as there is water over the slaked lime it will not change or lose its strength.

Whenever Bordeaux is spoken of as of a certain strength like "4-6-50" it must always be understood that it represents 4 pounds of Copper Sulphate and 6 pounds of lime to 50 gallons of water.

The first figure always stands for pounds of bluestone, the second for pounds of lime, and the last for gallons of water.

It is beyond the province of this bulletin to discuss the varied uses for Bordeaux mixture. Recommendations will be found in the spray calendar.

XVIII. Bordeaux and Arsenical Poison

It frequently happens that an arsenical poison must be applied for the control of some insect, when at the same time a fungicide is needed for controlling some disease. In such cases it results in great economy to use the Paris green, Green arsenoid or Arsenate of lead, or whatever poison may be used, with Bordeaux mixture as the carrier. The lime in the Bordeaux is sufficient to counteract the burning effect of the arsenicals, and the Bordeaux really helps to hold the poison longer than in any other way that it could be applied.

When poisons are used with Bordeaux use the same amounts recommended for use separately.

XIX. Ammoniacal Solution of Copper Carbonate.

In certain instances it is desirable to have a fungicide that can be applied to fruit without leaving a noticeable stain or coating. The black rot of grapes, for example, is a disease that must be treated when the fruit is nearly ripe, when a coating of Bordeaux would injure the appearance of the fruit. The ammoniacal solution of copper carbonate can be used in such a case. It is made as follows:

Copper Carbonate	5 ounces
Ammonia	3 pints
Water	50 gallons

Dissolve the copper carbonate in the ammonia. Keep the solution in a tightly stoppered bottle or glass jar until needed for use. This makes a very volatile spray, the ammonia soon evaporating on exposure to the air.

Caution:—Never attempt to use Paris green, or any similar poison with the above solution. The ammonia would dissolve the arsenic and cause severe burning of foliage.

XX. Copper Sulphate Solution.

Copper Sulphate	2 to 3 pounds
Water	50 gallons

Dissolve the copper sulphate in the water.

Fig. 3. Apple trees showing effect of one spraying with Bordeaux mixture as leaves were expanding. Orchard of Wayman & Riegel Pomona, Ga. Tree on left not sprayed. (From photo by author.)

This solution has often been recommended for early spring spraying of fruit trees. In certain rainless seasons it will do as well as Bordeaux mixture, but as the copper sulphate is soluble in cold water the solution is easily washed off by rains. Must never be used at above strength on plants in foliage. Sometimes used at rate of 2 ounces to 50 gallons of water on grapes when nearly grown.

XXI. Copperas (Iron Sulphate.)

Copperas has a limited value as a fungicide, but is not recommended here. The writer's reason for mentioning copperas is mainly to explain that Copper Sulphate and Copperas (Iron Sulphate) are *entirely distinct from each other,* so that no one should make the mistake of purchasing copperas when copper sulphate is desired.

XXII. Potassium Sulphide Solution.

Potassium sulphide (Liver of Sulphur)	1 ounce
Water	3 to 4 gallons

Employed with success against mildew on grape vines and other plants. It is also an effective insecticide to be used against certain soft-bodied insects, particularly red spiders and thrips on plants in greenhouses. The potassium sulphide solution must be kept in tight vessels as it changes on exposure to the air. The fungicidal value of this solution is not as great as the copper solutions, but it answers for mildews as they are not hard to destroy.

XXIII. Formalin or Formaldehyde. (40%)

For Potato Scab.

Formaldehyde (40%)	1 pint
Water	25 gallons

Seed potatoes may be treated before planting with the above strength of Formaldehyde solution, recommended by the Wisconsin Experiment Station.* The solution is placed in a barrel or other vessel and the potatoes tied up in loose sacks, submerged for 2 hours. They should afterward be spread out to dry.

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*Wisconsin Agricultural Experiment Station, Bulletin 98.

For Oat and Wheat Smut.

For smut submerge the wheat or oats, tied in sacks, in the solution for ten minutes. Then remove and spread out to dry. Or the grain may be piled in heaps on a tight floor, sprinkled with the solution and shoveled over to insure wetting every kernel; then cover with an oil-cloth for two or three hours. Dry the grain afterward. It may be found neeessary to treat seed oats three or four days before they are wanted for planting, otherwise they may not be thoroughly dry and will cause trouble in the seed drill. This treatment will cause the seed to enlarge slightly, and the germinating period may be shortened, hence seed grain should be treated only a few days previous to planting.

Formaldehyde solution may be used several times so that 25 or 30 gallons will treat a number of bushels of either potatoes or oats.

XXIV. Corrosive Sublimate. (Mercuric Chloride.)

For Potato Scab.

Corrosive Sublimate	2 ounces
Water	15 gallons

Dissolve the corrosive sublimate in hot water in an earthen or wooden vessel, and dilute to 15 gallons. Mix thoroughly to insure a uniform solution. The potatoes should be washed and tied in sacks and submerged for 2 hours. Remove and spread out to dry. After this the potatoes may be cut and planted as usual.

Caution:—Corrosive sublimate is a deadly poison internally, but the solution may be handled with perfect safety. It acts as a disinfectant for the hands and will benefit scratches or sores.

XXV. Carbon Bi-Sulphide.

This is a very useful insecticide for fumigating grain and other seeds to destroy weevils, and other insects. It is also used to fumigate houses to destroy rats, cock-roaches, bed bugs, carpet-beetles and many household pests. Ants in lawns and moles are often killed by this process.

Carbon bi-sulphide is a clear, colorless, volatile liquid, the fumes of which are highly explosive, and very disagreeable to smell. The fumes are deadly poison to all animal life if taken in sufficient quantity. People are safe while using it as the smell

is so repulsive that there is no danger of getting too great a dose unawares.

The fumes of carbon bi-sulphide are much heavier than air, so that fumigation with it is rendered easy. Grain may be treated in boxes or bins having tight sides and bottom by simply placing the liquid in shallow pans on top of the grain and covering all with a blanket or boards to prevent a circulation of air. Use from three-fourths to one and a half pounds of carbon bi-sulphide to each 1000 cubic feet of space, or in round numbers, one pound to 100 bushels of grain or other seed. Let the bin remain covered for at least 24 hours. Grain or seed treated in this manner is not impaired for planting purposes, its germinating power not being affected. For corn, oats, beans, peas and the like which will not be used for seed it will often pay to use 2 pounds of carbon bi-sulphide to each 100 bushels.

To destroy underground forms of insects use two to three ounces of carbon bi-sulphide per square yard, placed in little holes in the earth made with a sharpened stick, and closed by pressing with the heel after pouring in the liquid. This liquid must be used with care around growing plants, but may be used in small quantities on lawns to destroy ants and moles.

When fumigating houses remove all chance of fire and use about three to four pounds of carbon bi-sulphide per 1000 cubic feet. Allow the house to remain closed for 36 hours.

Caution:—Never expose carbon bi-sulphide in a room with a lighted lamp or any form of fire. Remember that the fumes are highly explosive.

LIST OF INSECTICIDES AND FUNGICIDES.

The following list includes all insecticides and fungicides discussed in this bulletin. The Roman numerals before each name, when used in the calendar, refer to the materials as shown in this list and in the body of the bulletin.

I. Paris Green (as a spray).
II. Paris Green (dry).
III. Green Arsenoid.
IV. London Purple.
V. Arsenite of Lime.
VI. Arsenate of Lead
VII. Lime-Sulphur-Salt Wash.
VIII. Lime-Sulphur Wash.
IX. Lime-Sulphur-Soda Wash.
X. Kerosene Emulsion.
XI. Tobacco.
XII. Whale Oil Soap.
XIII. Adhesive Resin Wash.
XIV. Pyrethrum.
XV. Hellebore.
XVI. Poisoned Bait.
XVII. Bordeaux Mixture.
XVIII. Bordeaux and Arsenical Poison.
XIX. Ammoniacal Copper Carbonate.
XX. Copper Sulphate Solution.
XXI. Copperas.
XXII. Potassium Sulphide Solution.
XXIII. Formalin or Formaldehyde.
XXIV. Corrosive Sublimate.
XXV. Carbon Bi-Sulphide

SPRAY CALENDAR—Continued.

NAME OF PLANT.	Name of Insect or Disease.	WITH WHAT TO SPRAY.	WHEN TO SPRAY, OR OTHER TREATMENT. First.	Second.	Third.	Fourth.	*REMARKS AND CAUTIONS.
Apple	Borers	Cannot be reached by spraying	Remove borers in Oct. and Nov.	Look again for borers in March			Hunt for borers in trunk near ground. Remove with knife.
	Aphis (on leaves)	Tobacco decoction, or X or XII	Just as buds open if lice appear	5 days later	Repeat first if necessary		Watch closely; spray before leaves become curled.
	Bud worm	Arsenical in Bord.	I or VI in XVIII when leaf buds open	Repeat 5-6 days later.			
	Canker Worms	Arsenical in Bord.	I or VI in XVIII when worms appear	10 days later if worms remain			Wrap trunks of trees in spring with loose cotton to prevent females from crawling up.
	Codling moth (apple worm)	Arsenical in Bord.	I, III or VI in XVII just after petals fall	Repeat before calyx closes	Repeat at once if rains occur after second		Important to spray before fruit turns down. Gather fallen fruit.
	Fall web-worm Tent caterpillar	Arsenicals	I, III, V or VI when worms appear	8-10 days later	8-10 later if necessary		Remove or burn nests when first seen, about night or cloudy day.
	San Jose Scale	Lime-Sulphur wash.	During Dec. or Jan.	Repeat in Feb. on bad trees			Wash trunk and main limbs with VII or VIII during summer.
	Woolly aphis	Tobacco and X or XII	X or XI for aerial form on limbs	Repeat if necessary			See use of tobacco for root form. Tobacco decoction best for aerial form.
	Bitter rot	Bordeaux	XVII (4-5-60)† 5-6 weeks after petals fall	2 weeks later	2 weeks later	2 weeks later	Spray oftener during warm, damp weather.
	Leaf blight	Bordeaux	XVII (4-6-50)† when leaves are fully expanded	10-12 days later	10-12 days later		

*For information about insects or diseases not mentioned herein apply to the State Entomologist, Atlanta, Ga.

*See explanation of this formula in discussion of Bordeaux Mixture on page 150.

SPRAY CALENDAR—Continued.

NAME OF PLANT.	Name of Insect or Disease.	WITH WHAT TO SPRAY.	WHEN TO SPRAY, OR OTHER TREATMENT. First.	Second.	Third.	Fourth.	REMARKS AND CAUTIONS.
pple—(cont'd)	Rust (leaves and stems)	Bordeaux	XVII (4-6-50)* when leaves are fully expanded	10-14 days later	10-14 days later		This disease starts on cedar trees. Removal of such will prevent trouble.
	Scab (leaves and fruit)	Bordeaux	XVII (6-6-50)* just before leaf buds open	XVII (4-6-50) just be fore blossoms open	Few days after blossoms fall	10-14 days	Additional spraying every 10-14 days if necessary
sparagus	Asparagus beetle	XIV during cutting season	Lime and XIV when young appear	3-4 days later	3-4 days later	3-4 days later	After through cutting use VI or XIII. Shake beetles and larvae on hot soil on sunshiny day.
	Asparagus rust (leopard spot)	Bordeaux	After cutting crop use XVII (3-6-50)*	Repeat 10 days later	10-12 days later	10-12 days later	Clean up and burn all diseased brush in fall
ean	Leaf beetle	Arsenicals	I or VI alone or with XVII when beetles appear	10 days later	Repeat if necessary		
	Bean weevil	Carbon bi-sulphide	When beans are stored in fall				Read discussion under XXV.
	Anthracnose	Bordeaux (weak)	On 2-3 inch plants	10-12 days later	10-12 days later	10-12 days later	Use I, III or VI with XVII and control biting insects also.
	Rust	Bordeaux (weak)	Same as Anthrac	Same as Anthrac	Same as Anthrac		
uliflower bbage llard	Aphis (green lice)	Contact poisons	X, XI or XII when insects appear	Repeat 5 days later	Repeat if necessary		Tobacco decoction may be used.
	Cabbage worm (*plusia*)	Arsenicals and Pyrethrum	I, III or V in XIII at first appearance	5-10 days later	Repeat if worms remain		Use XIV when heads are nearly grown.
	Harlequin bug Sucking bugs	Contact poisons	X or XII at first appearance	5-6 days later	Repeat if necessary		Plant kale and mustard as trap crop. Destroy bugs with pure kerosene on these plants.

*See explanation of this formula in discussion of Bordeaux Mixture on page 150.

SPRAY CALENDAR—Continued.

NAME OF PLANT.	Name of Insect or Disease.	WITH WHAT TO SPRAY.	WHEN TO SPRAY, OR OTHER TREATMENT.				REMARKS AND CAUTIONS.
			First.	Second.	Third.	Fourth.	
Cantaloupe or Muskmelon Watermelon	Club foot or club root	Lime in soil					Rotate crops.
	Melon louse	Contact poisons and XXV	X, XI or XII when lice appear	4-5 days later	Repeat if insects remain		XXV is used in tight boxes placed over young plants. One spoonful to each hill. Sprays must be applied to under side of leaves.
	Striped beetles, flea beetles, etc.	Arsenical in Bord	XVIII on young plants	Repeat in ten days	If necessary to keep plants protected		Land plaster, air slaked lime, tobacco dust, etc., are used as repellents.
	Squash bug	Handing picking and repellents	XVII as repellent on young plants	X or XII when first young appear	Repeat in few days		Adult bugs are picked by hand and trapped under sticks and boards.
	Blight; mildew	Bordeaux	XVII (3-6-50)* on young plants	8-10 days later	8-10 days later	8-10 days later	Pull out dying plants. Practice rotation of crops.
Carnation	Leaf spot Rust	Bordeaux or XIX	XVII (2-4-50)* or XIX when plants are set	Repeat at first sign of disease	10-14 days later	10-14 days later	
Celery	Caterpillars	Arsenical in Bord	When caterpillars appear	Repeat in 10 days if necessary			Use weak Bordeaux and small per cent of poison.
	Leaf spot or blight	Bordeaux or XIX	XVII (3-6-50)* on young seedlings	10 days later	Same when plants are set	Repeat 10 days later	Use XIX when plants near maturity.
Chrysanthemum	Leaf spot	Bordeaux (weak)	On young cuttings	10-14 days later	10-14 days later	Repeat if necessary	Select healthy plants for making cuttings.
Cherry	Aphis	Contact poisons	X, XI or XII as insects appear	5-7 days later	Repeat if necessary		Watch trees closely; spray before leaves become curled.

SPRAY CALENDAR—Continued.

NAME OF PLANT.	Name of Insect or Disease.	WITH WHAT TO SPRAY.	WHEN TO SPRAY, OR OTHER TREATMENT. First.	Second.	Third.	Fourth.	REMARKS AND CAUTIONS.
Cherry—(cont'd)	Curculio	Jarring and Arsenical in Bord	When first leaves appear, I or VI in XVIII	When fruit is first set	Repeat in 10 days		Jar trees over sheets to capture beetles. Repeat every two days. Destroy all fallen fruit.
	San Jose scale	Lime-Sulphur wash	During Dec. or Jan.	Again in February			See apple.
	Slug (on leaves)	Contact or internal poison	I or III in XVIII or X when slugs appear	Repeat in 10 days	Repeat if necessary		Air-slaked lime or even road dust will kill young slugs.
	Brown Rot	Bordeaux	XVII (5-6-50)* before blossoms open	XVII (3-8-50) when fruit is set	Repeat 10-14 days later	Repeat 10-14 days later	Use XIX when fruit is half grown. Remove mummied fruit in winter.
	Black knot	Cut out diseased limbs	(See remarks)				When Bordeaux is used Black Knot is not liable to spread.
	Leaf spot or blight	Bordeaux	XVII (3-8-50)* when leaves are ½ grown	Repeat 10-12 days later	Repeat 10-12 days later		XIX to avoid marking fruit.
Cotton	Cotton louse	Contact poison	X or XII when lice appear	6-8 days later if necessary			Treatment not always required.
	Boll worm	Arsenicals	II or VI when worms appear. July	8-10 days later	Watch for next brood		Plant corn as trap crop. (See Bull. No. 16.)
	Cotton caterpillar	Arsenicals	II or VI when caterpillars appear	8-10 days later			Caterpillars first appear on under side of leaves. Poison while young.
	Red spider	Contact poison	X or XXII when mites appear	Repeat 5-6 days later	6-8 days later		Dust plants with lime, or plaster and sulphur.

*See explanation of this formula in discussion of Bordeaux Mixture on page 150.

SPRAY CALENDAR.*

NAME OF PLANT.	Name of Insect or Disease.	WITH WHAT TO SPRAY.	WHEN TO SPRAY, OR OTHER TREATMENT.				REMARKS AND CAUTIONS.
			First.	Second.	Third.	Fourth.	
Cotton—(cont'd)	Anthracnose	(See remarks)					Constant use of Bordeaux might prevent. Depend mainly on selection and breeding of resistant plants.
	Black root or wilt disease	Spraying not effective	Remove diseased plants				Build up a resistant cotton by selection of healthy plants in diseased fields.
Currant	Currant worm or slug	Lime, Pyrethrum or road dust	Dust leaves when worms appear	Repeat in few days	Repeat if necessary		Look for worms on under side of leaves.
	Leaf spot	Bordeaux (weak)	XVII (3-6-50)* as leaves open	10-14 days later	10-14 days later	Repeat if necessary	
Cucumber Squash	See Cantaloupe						
	Squash vine borer	Cannot be prevented by spraying	(See remarks)				Remove borers from stalk. Burn old vines. (See Bull. 10)
Egg Plant	Colorado potato beetles; flea beetles	Arsenicals alone or in Bord	II, VI or XVIII when beetles appear	Repeat 8-10 days later	Repeat if necessary		When dust method is used, keep plants well covered.
	Leaf spot	Bordeaux or XIX	XVII (3-6-50)* when plants are established	10-14 days later	Use XIX if fruit is set	Repeat third 10 days later	Use XIX as fruit nears maturity.
Fig	Mealy bug	Contact poison	X or XII when bugs appear	Repeat 5 days later	Repeat when necessary		Spray with great force to wash off insects.
Grape	Flea beetle	Arsenical in Bord	I or VI in XVIII as buds open	Repeat when beetles appear	10-12 days later		Larvae on leaves may be killed with lime dust or XIV.
	Grape slug	Arsenical or contact poison	VI in XVIII, or X or XIV when slugs appear	Repeat in 5-8 days			These insects feed in groups, easily destroyed.

†See explanation of this formula in discussion of Bordeaux Mixture on page 150.

SPRAY CALENDAR—Continued.

NAME OF PLANT.	Name of Insect or Disease.	WITH WHAT TO SPRAY.	WHEN TO SPRAY, OR OTHER TREATMENT.				REMARKS AND CAUTIONS.
			First.	Second.	Third.	Fourth.	
Grape—(cont'd)	Leaf folder	Arsenicals	I or VI alone or in XVIII when worms appear	6-8 days later repeat	8-10 days later if worms remain		Watch vines closely; spray before leaves are folded.
	Anthracnose	Bordeaux and XIX	XVII (5-6-50)* just before buds open	Repeat before blossoms appear	XVII (4-6-50)* when fruit is set	XIX two weeks later	Continue use of XIX if necessary.
	Downy mildew	Bordeaux	XVII (4-6-50)* just before blossoms appear	When fruit is set	10 days later		
	Rots	Bordeaux and XIX	Same as for mildew	Same as for mildew	Same as for mildew		Continue XIX every 10-14 days until fruit is ripening.
Oat	Oat smut	See XXIII for treatment of seed					This smut causes the head to turn into a black mass.
Orange	Cottony cushion-scale	Kerosene emulsion, 15% or XII	When fruit is one-fourth grown	2 weeks later			This scale is controlled in Cal. by a lady bug (*Novius cardinalis.*)
	San Jose Scale	Lime-Sulphur wash	When trees are dormant	Kerosene emulsion 15% in summer			Depend on winter spraying.
	White fly	Contact poisons	About last of April use X or XII	10-12 days later	Same when second brood appears	Repeat if necessary	XIII may be used without poison. Will adhere well.
	Scab	Bordeaux or XIX	XVII (3-6-50)* or XIX just after blossoms fall	Repeat 2-3 weeks later	2-3 weeks later		
	Sooty mold	See Remarks					Lives on honey-dew from white fly. Remedy lies in preventing the white fly.

*See explanation of this formula in discussion of Bordeaux Mixture on page 150.

NAME OF PLANT.	Name of Insect or Disease.	WITH WHAT TO SPRAY.	WHEN TO SPRAY, OR OTHER TREATMENT. First.	Second.	Third.	Fourth.	REMARKS AND CAUTIONS.
each	Black peach aphis (leaf form)	Contact poison	X, XI or XII when lice appear	6-8 days later			Spray before leaves curl. For root form use tobacco dust.
	Borers	Repellent wash	(See remarks)				(See Bulletin No. 17.)
	Curculio	Jarring or arsenical in Bord	Commence jarring, and use VI or XVIII as petals fall	8-10 days later	8-10 days later	8-10 days later	Jar trees to capture beetles every day for 2-3 weeks after fruit sets. (See Bul. No. 17).
	Peach twig borer	Lime-Sulphur wash	VII or VIII during winter	I or VI in XVII as buds are opening			Winter treatment with VIII destroys young larvae in winter cells.
	San Jose scale West Indian scale Peach lecanium	Lime-Sulphur washes and X	During winter months use VII or VIII	Repeat on bad trees before buds open	X (20%) when fruit is half grown		Depend on winter spraying.
	Brown rot and mildew	Bordeaux (weak)	XVII (5-6-50)* before buds open	XVII (3-9-50)* when fruit is set	10-14 days later	10-14 days later	XIX when fruit nears maturity. In winter remove mummied fruit and dead twigs.
	Leaf curl	VII or XVII (4-6-50)*	Spray one month before buds open	Touch up unsprayed spots			One spraying enough if well done.
ecan	Bud worm	Arsenicals	I, III or VI when buds open	10-12 days later			XVIII may be used with profit.
	Scab (leaves and nuts)	Bordeaux	XVII (6-6-50)* about March 1st	XVII (4-6-50)* when foliages fully grown	When nuts are one-third grown	2-3 weeks later	I or VI may be used in XVIII and will destroy caterpillars.
ear	Bud worm	Arsenical in Bord	Same as for apple	Same as for apple			See apple.
	Codling moth	Arsenical in Bord	Same as for apple				See apple.

*See explanation of this formula in discussion of Bordeaux Mixture on page 150.

SPRAY CALENDAR—Continued.

NAME OF PLANT.	Name of Insect or Disease.	WITH WHAT TO SPRAY.	WHEN TO SPRAY, OR OTHER TREATMENT. First.	Second.	Third.	Fourth.	REMARKS AND CAUTIONS.
Pear—(cont'd).	Pear slug	Arsenicals	I or VI in XVIII when slugs appear	10 days later if slugs remain			See cherry.
	San Jose scale	Lime-Sulphur wash	VII or VIII during winter				See peach.
	Pear leaf blight	Bordeaux	XVII (4-6-50)* when leaves get full grown	Repeat 2-3 weeks later	3 weeks later		Third spraying not often necessary. Pear stocks may be sprayed 5-6 times.
	Pear scab	Bordeaux	Same as for apple				See apple.
Plum	Aphis	Tobacco decoction	When lice appear	6-8 days later if necessary			X or XII in weak solution may be used.
	Curculio	Jarring and arsenicals	Same as for peach				See peach.
	San Jose scale Lecanium scale	Lime-Sulphur washes	During the winter	X (15%) in summer if necessary			See apple and peach.
	Shot-hole borer	Repellents	Remove infested trees during winter	Paint trunks in spring with repellent			(See Bulletin No. 17).
	Brown rot	Bordeaux	Same as for peach	Same as for peach	XIX when fruit is set.	Repeat with XIX	(See peach.)
	Plum pocket	Bordeaux	XVII (4-6-50)* before buds open				Give same treatment as for peach leaf curl.
	Shot-hole fungus	Bordeaux (weak)	XVII (3-6-50)* when leaves are nearly grown	XVII (3-9-50)* two weeks later	Repeat 2-3 weeks later		

*See explanation of this formula in discussion of Bordeaux Mixture on page 150.

SPRAY CALENDAR—Continued.

NAME OF PLANT.	Name of Insect or Disease.	WITH WHAT TO SPRAY.	WHEN TO SPRAY, OR OTHER TREATMENT. First.	Second.	Third.	Fourth.	REMARKS AND CAUTIONS.
Potato	Colorado potato beetle; blister beetles	Arsenical in Bord, or II	When beetles or young appear	8-10 days later if spray is used	If insects again appear		Use strong mixtures. Dry poison must be applied often. XVIII is most successful.
	Flea beetles	Repellent or arsenical	When beetles appear	5-8 days later	Repeat if necessary		Bordeaux with poison is best. Dusting will sometimes answer.
	Potato blight	Bordeaux	When plants are 4-5 inches high	Repeat 10-14 days later	10-14 days later		Use XVII (4-6-50) and add I or VI for insects.
	Scab	XXIII or XXIV	Soak seed potatoes				See use of XXIII or XXIV against scab.
Quince	Slug	Contact or internal poison	I, X or XVIII when slugs appear	Few days later if necessary			See cherry.
	Leaf blight	Bordeaux	Same as for pear	Same as for pear			See pear.
	Rust	Bordeaux	XVII (4-6-50)* when leaves are half grown	After blooming	2 weeks later		See apple rust.
Raspberry Blackberry Dewberry	Rose scale San Jose scale	Lime-Sulphur washes	VII or VIII when dormant				Cut and burn worst infested canes
	Slug	Contact poison or VI	I, VI, X or XII when slugs appear	Repeat 4-5 days later	Repeat if necessary		Poison spray should not be used on bushes in fruit.
	Anthracnose	Bordeaux	XVII (5-6-50)* before growth begins	XVII (3-6-50)* soon after growth begins	8-10 days later	8-10 days later	Use XIX on bearing bushes when fruit is half grown.
	Orange rust		Cut out diseased canes				Spraying for anthracnose may prevent.

*See explanation of this formula in discussion of Bordeaux Mixture on page 150.

SPRAY CALENDAR.*

NAME OF PLANT.	Name of Insect or Disease.	WITH WHAT TO SPRAY.	WHEN TO SPRAY, OR OTHER TREATMENT. First.	Second.	Third.	Fourth.	REMARKS AND CAUTIONS.
Rose	Rose beetle or rose chafer	Hand picking and arsenicals	Begin by hand picking each day	I or III (1 lb. to 100 gallons)	Repeat in few days		Use of arsenicals somewhat uncertain.
	Rose slug	Arsenicals or X or XII	I, VI, X or XII when slugs appear	4-5 days later	4-5 days later if necessary		May be well to apply both contact and arsenical poisons.
	San Jose scale Rose scale	Lime-Sulphur washes	In winter				Remove and burn badly infested sprouts.
	Leaf spot	Bordeaux or XIX	XVII (3-6-50)* or XIX when leaves appear	Repeat 10-14 days later	Repeat if necessary		XIX will not show much on foliage.
Strawberry	Leaf roller, slug, etc.	Arsenical in Bord.	When insects appear	6-8 days later	Repeat if necessary		
	Tarnished plant bug	Kerosene emulsion	X (15%) on young plants	Same before fruit is ripening	Use XIV when fruit is ripening		Kerosene emulsion may taint fruit. Pyrethrum should be used as spray.
	Leaf blight or rust	Bordeaux (weak)	When growth begins	10-14 days later	XIX when fruit is set	Repeat third if necessary	On young beds and after fruit is gathered use XVII every two weeks.
	Mildew	Potassium sulphide	When growth begins	6-8 days later if mildew appears	Repeat if necessary		When Bordeaux is used, mildew not liable to appear.
Tobacco	Bud-worm	Poisoned bran	XVI sprinkled in opening buds	Repeat in 5-6 days	Repeat as necessary		Watch closely for first worms.
	Cutworms	Poisoned bran	XVI spread on land before planting	XVI, spoonful at base of plants	Repeat 2-3 days later		Poisoned bait should be applied about sundown.
	Horn worm	Hand picking and arsenicals	I or VI when worms appear	6-8 days later	When second brood appears		Hand pick large worms. Spray to destroy small worms. Turkeys will capture many.

†See explanation of this formula in discussion of Bordeaux Mixture on page 150.

SPRAY CALENDAR—Continued.

NAME OF PLANT.	Name of Insect or Disease.	WITH WHAT TO SPRAY.	WHEN TO SPRAY, OR OTHER TREATMENT. First.	Second.	Third.	Fourth.	REMARKS AND CAUTIONS.
Tomato	Colorado potato beetle; flea beetles, etc.	Arsenicals in Bord.	Same as for potato	Same as for potato			
	Tomato worm; Fruit worm	Hand picking and arsenicals	I, III or VI in XVIII when worms appear	6-8 days later	Repeat if necessary		
	Blight	Bordeaux	XVII (3-6-50)* while in seed bed	When plants are set out	10-14 days later	10-14 days later	XIX may be used every two weeks until fruit nears maturity.
Violet	Leaf rust or spot	Bordeaux	When first disease appears	10-14 days later	10-14 days later	10-14 days later	Burn all diseased leaves and plants.
Turnips and Radishes	Cabbage web-worm	Arsenicals	I, III or VI when worms appear	5-6 days later	8-10 days later		Must be poisoned when first appearing before webs are formed over plants.
Wheat	Smut	See XXIII for treatment of seed					
Sweet Potato	Golden bugs; flea beetles, etc	Arsenical in Bord	XVIII in seed bed	Dip plants in VI or XVIII before planting	Repeat first 10-12 days after planting	Repeat if necessary	Plants not often injured after getting well started.
	Leaf spot, leaf mold, etc	Bordeaux	XVII (4-6-50)* when plants are set	Repeat at first sign of disease	10-12 days later		

*See explanation of this formula in discussion of Bordeaux Mixture on page 150.

DIRECTIONS FOR SENDING INSECTS AND PLANTS.

This office is at all times glad to render all possible assistance to fruit growers and farmers, by determining the identity of insects and plant diseases, and advising measures for their control.

When sending insects observe the following precautions :

Never send insects of any kind in envelopes or pasteboard boxes ; they are generally crushed beyond recognition. Living insects should be enclosed in strong, tight, wooden or tin boxes. No openings for air are necessary.

Enclose some of the food-plant for insects to subsist on while enroute. The name and address of sender should be on every package.

It is against the postal regulations to enclose a letter in a package by mail, unless the package is sent at regular letter postage rate. The postage required on packages containing insects or plants is one cent for each ounce.

Correspondents are requested to write as full a description as possible, of the habits, food-plants, injury and abundance of insects sent for identification.

Beneficial insects, as well as injurious forms, are always gladly received. A letter should be sent also, stating in what way the insects are beneficial.

Specimens of twigs, living plants with foliage, etc., should be wrapped in moist cloth or paper to insure their reaching us in fresh condition. Fruit showing injury or disease should always be wrapped in paper and packed carefully in a strong wooden or tin box.

Address communications to

R. I. SMITH,

STATE ENTOMOLOGIST.

The bulletins of the Georgia State Board of Entomology, which are of present practical value, and still available, are mentioned below. (The numbers not mentioned are either out of date or exhausted.) Application for any of these numbers should be addressed to the State Entomologist, Atlanta, Ga.

Bulletin No. 6—The Peach Leaf Curl and its Treatment.

Bulletin No. 9—The Cotton Caterpillar.

Bulletin No. 10—The Crop Pest Law of Georgia. (Not including Amendments of 1904–05.)

Bulletin No. 11—Fumigation of Nursery Stock.

Bulletin No. 12—Mexican Cotton Boll Weevil.

Bulletin No. 13—Some Common Insects Injurious to the Apple.

Bulletin No. 14—Experiments With the San Jose Scale in 1904.

Bulletin No. 15—Cyanide Method of Fumigating Nursery Stock.

Bulletin No. 16—Cotton Boll Worm and Insects Injurious to Corn and Truck Crops.

Bulletin No. 17—Peach Insects. A treatise on the important Peach Insects in Georgia.

Bulletin No. 18—Pear Blight Disease in Georgia, and Pear Leaf Blight.

GEORGIA

STATE BOARD OF ENTOMOLOGY

BULLETIN NO. 20—SEPTEMBER, 1906.

PART I.

Report of the State Entomologist

FOR 1905

And Insects of the Year

PART II.

Crop Pest Law of Georgia

Regulations of the Georgia State Board of Entomology

CAPITOL BUILDING — Atlanta, Ga.

See Notice on Last Page of Cover

OPELIKA, ALA.
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1906

GEORGIA STATE BOARD OF ENTOMOLOGY.

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Field Assistant Entomologist, Atlanta.

G. R. CASEY,

Deputy Inspector, Adairsville.

W. W. CHASE,

Deputy Inspector, Atlanta.

To the Honorable Board of Entomology of the State of Georgia:

I have the honor of submitting a report of the work of the Board of Entomology for the year 1905, and recommend that it be printed and distributed in bulletin form for the benefit of the fruit growers and farmers of the State.

All who are interested in this Board and its work should be given an opportunity of knowing the character of the work which we are doing. Many people in the state are not yet familiar with the different lines of work undertaken. This information, widely distributed, should tend to increase the interest in our work which is generally conceded as being one of great importance. Several new lines of investigation have been started within the last two years. Experiments looking to the control of the cotton wilt disease, or "black root," and demonstration work in control of the pear blight are now occupying considerable time and while the work is incomplete it cannot well be reported on in our bulletins.

I recommend also the publication of the amended Crop Pest Law, including the sections relative to quarantine against the Mexican cotton boll weevil, and also the revised Rules and Regulations of the Board, as a supplement to the report already mentioned. Within the last two years our mailing list has been increased by over 3000 names, composed of prominent fruit growers and farmers in all parts of Georgia. These new correspondents have never received a bulletin giving the Law governing this Board. As many requests are received for a copy of the Law and Regulations it seems desirable to publish them in full.

Very respectfully,

R. I. Smith,
State Entomologist.

Approved:
T. G. Hudson, Chairman of the Board.
Sept. 5, 1905.

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BULLETIN

OF THE

Georgia State Board of Entomology.

SEPTEMBER, 1906. **No. 20.**

Published by the Georgia State Board of Entomology, Atlanta, Ga., and sent free of charge to all residents of the State who make request for same.

PART I.

REPORT OF STATE ENTOMOLOGIST OF GEORGIA FOR 1905.

BY R. I. SMITH, STATE ENTOMOLOGIST.

To the Honorable Members of the Georgia State Board of Entomology:

I have the honor to submit herewith, as State Entomologist and Secretary of the Board, a Report on the work of the State Board of Entomology for the period between January 1st, 1905, and December 31st, 1905.

The year has been notable for the number of changes and additions to the working force of the Board, chief among which was the resignation of your former State Entomologist, Mr. Wilmon Newell. Although he is to be congratulated on gaining a better position, we must regret the loss of his valuable services in Georgia.

The work during 1905 has been carried on along much the same lines as formerly, and in addition some new fields of research and experimentation have been entered. More work in orchard inspection has been possible, with the increased appropriation over 1904, and this work has been pushed into new fields. Regular routine nursery inspection

has been given even more careful attention than in the past. The office work has shown about 20 per cent increase in the number of letters received and answered. This feature of the work is of great importance and indicates that the people of the State are becoming more alive to the demands for greater knowledge regarding the control of insects and diseases in the orchards and general farm crops.

PERSONNEL OF THE WORKING FORCE.

For 1905 the personnel of the Board has been as follows: From January 1st to February 14th, Mr. Wilmon Newell was State Entomologist, with A. C. Lewis and the writer as assistants. On February 14th the writer was advanced to the position of State Entomologist, Mr. Newell having resigned to accept a better and more remunerative position as Entomologist to the Louisiana Experiment Stations. After February 14th Mr. Lewis continued to act as Assistant Entomologist, filling the position with credit and taking an active interest in the work. After Mr. Newell resigned it became necessary to select another assistant and Harper Dean, Jr., a graduate of the Virginia Polytechnic Institute, was selected, and has rendered highly efficient service. Mr. Dean* has been known as Field Assistant. His work has been mainly nursery and orchard inspection and experimental work. Since August 1st, W. W. Chase, also from the Virginia Polytechnic Institute, has acted as Deputy Inspector on orchard and nursery inspection. Mr. G. R. Casey, of Adairsville, Ga., has also acted as Deputy Inspector and both these gentlemen have rendered valuable services. The work done by Mr. Casey has been confined mainly to Northwest Georgia, in order to reduce the expense of traveling. As office help Miss Bettie Walker has rendered valuable assistance. And in this connection I wish to say that the increased correspondence and office work has made the duties of the stenographer much more arduous than in past years.

*Harper Dean, Jr., resigned in March, 1905, and his place is filled by W. V. Reed, of Mississippi.

ANNUAL APPROPRIATION.

The appropriation for the State Department of Entomology for 1905 was $10,000.00, $3,000.00 more than for 1904. This increased amount has made it possible to do more extensive and more efficient work than here-to-fore, as will be evident from the detailed report farther on.

The changes in the working force of the Department and the consequent interruption of work made it difficult to arrange all plans to the best advantage without fear of over-reaching the amount appropriated, and hence instead of using the entire $10,000.00, as could easily have been done, we have come through the year with $503.82 balance. This amount will be added to the appropriation for 1906, and the whole amount can be utilized to good advantage.

I am constrained to mention the matter of railroad passes as effecting our work. During 1905, I was granted passes by all but one large railroad and my assistant held passes over several lines. We have secured about the same number this year. However, the point I wish to mention is that the traveling expenses of assistants not holding passes are very high, and as our work increases, the amount spent for traveling will increase, and at a noticeable rate, not wholly in keeping with the amount of work accomplished. Without passes our work would have been reduced considerably last year.

FARMER'S INSTITUTE WORK.

Farmers Institutes demand considerable attention during summer and fall. Talks on insects and plant diseases have been made at several points over the State. This work was made a special feature of the work of your Department by the General Assembly of 1904. We have arranged to give more valuable aid to Farmers Institute work by the purchase of a stereopticon for giving illustrated lectures.

INSECTS OF THE YEAR 1905.

The insects of the Year were reported at a meeting of

the Association of Economic Entomolgists at New Orleans. In that paper mention was made of 35 common and more or less destructive insects, and the number would have been considerably increased if mention had been made of all minor out-breaks. The report was as follows:

Insects of the peach, apple, cotton, corn, grass and grain crops are the ones that command the most attention each year in Georgia. During the season of 1905 several injurious forms have appeared on each of these crops, while in addition some insect pests of minor crops have been brought to our attention.

PEACH INSECTS.

The SAN JOSE SCALE, *Aspidiotus perniciosus,* still heads the list of scale insects in Georgia as being the best known and the most pernicious. The winter application of lime-sulphur-salt wash has proved to be an effectual remedy for this pest. One spraying in late winter is usually sufficient, though badly infested orchards are sometimes treated twice during the winter; preferably in December and February.

For summer treatment of San Jose scale we recommend using 20 per cent kerosene-soap emulsion on peach trees when the fruit is about one inch in diameter, or just after the fruit is gathered. Soluble petroleum oils have not been sufficiently tested in Georgia to justify our either recommending or condemning their use.

The CHERRY SCALE, *Aspidiotus forbesi,* is common in many orchards but not often numerous enough to require spraying.

PEACH LECANIUM, *Eulecanium nigrofasciatum*, has been found in a few peach and plum orchards this year. It is generally kept in control where lime-sulphur-salt wash is used during the winter.

THE WEST INDIAN PEACH SCALE, *Aulacaspis pentagona*, is still present in a few localities in middle and South Georgia.

The PEACH-TREE BORER, *Sanninoidea exitiosa*, continues to be one of the most dreaded of peach insects. Repellent washes have not proved to be satisfactory in preventing the

depredations of this pest. Work done by Prof. H. N. Starnes, of the Georgia Experiment Station, goes to show that mounding the earth around the base of peach trees about August 1st to compel the borer larvae to establish themselves well up on the trunks, and the early removal of these mounds, about the last of October, followed by thorough scraping and worming and application of some caustic wash, is the most satisfactory way of fighting this insect. This work may be supplemented by spring worming if necessary.

THE FRUIT-TREE BARK BEETLE, *Scolytus rugulosus*, has been more in evidence this year than commonly; and this we think is due largely to the fact that many peach trees were injured by the cold winter of 1904-05, rendering them more susceptible to attacks from this insect. During June and July many letters were received from all parts of Georgia, stating that the bark-beetle, or shot-hole borer, as it is more commonly called in Georgia, were killing numbers of trees in the young orchards. Investigation of several of these cases revealed the fact that many of the trees thus reported as being killed by the shot-hole borers, had been previously injured and weakened by peach borers, cold weather, or through injury by cultivation or lack of same. In a few cases, however, apparently healthy trees were being badly attacked, leading us to the conclusion that healthy trees are sometimes seriously injured by the bark-beetle, in spite of opinions, by eminent authorities, to the contrary.

Numerous orchards last spring showed the work of the PEACH-TWIG BORER, *Anarsia lineatella,* but the damage resulting was not great. Orchards which had been sprayed the winter before with lime-sulphur wash were for the most part uninjured.

The PLUM CURCULIO, *Conotrachelus nenuphar,* was abundant during 1905 in many orchards and caused considerable loss of fruit. Much good work toward controlling this insect in Georgia is done each year by gathering all fallen fruit every two or three days, this practice being followed by many of our largest orchardists. The jarring method

for capturing the beetles is practiced in some few orchards with good result, but this method of fighting the curculio is not generally accepted because of the amount of labor necessary to successfully carry out the operation.

The SOUTHERN JUNE-BEETLE, *Allorhina nitida,* was observed June 29, '05 at Baldwin, Georgia, eating the leaves off the young shoots of peach trees.

On April 8th, a nurseryman at Rome, Georgia, sent specimens of the TARNISHED PLANT-BUG, *Lygus pratensis,* and stated that they were severely injuring pear stock in the nursery rows. May 22nd a similar report came from Buff. Georgia, except that the insects were working on young apple grafts. We advised spraying with kerosene emulsion at 15 per cent strength, which was found to be successful.

SCALE INSECT OF OAK AND MAPLE.

The GLOOMY SCALE, *Aspidiotus obscurus,* is found in nearly all parts of Georgia on the oaks and maples. In the city of Atlanta it is almost impossible to find a tree not infested.

APPLE INSECTS.

Several common APPLE INSECTS have been injurious in Georgia this year, among which the following are the most important:

The WOOLLY APHIS of the APPLE, *Schizoneura lanigera,* is nearly everywhere abundant and particularly in the older apple orchards. The aerial form is not serious, nearly all the injury from this insect coming from the ground form where it is too often allowed to increase unmolested. Tobacco dust has been used with some success on the young orchards, but we have found it necessary to make at least two applications of dust each year to insure even partial success.

A series of experiments were started by our Department with a view of finding a good remedy for the under-ground form. The work was mainly conducted by Harper Dean, Jr., Field Assistant Entomologist, and the result of the first year's work has been reported in the proceedings of

the Georgia State Horticultural Society for 1905. The work with tobacco dust was not entirely successful; other forms of tobacco, alone, and with kainit, also gave doubtful results. Kerosene emulsion at 20 and 30 per cent was found to be the best remedy, but further tests will be made before it is generally recommended. We have found that kerosene emulsion may be used in which to dip the roots of nursery stock without apparent injury to the trees. We have controlled the aerial form in the usual way.

The CODLING MOTH, *Carpocapsa pomonella,* has been noticed more or less in all apple orchards. In the best apple orchards of Georgia proper spraying methods are followed and this insect reduced to a considerable extent.

The APPLE PLANT-LOUSE, *Aphis mali,* was present in a number of orchards, and in a few cases the damage to young trees was quite severe. We have found that a strong tobacco decoction is somewhat superior to kerosene emulsion for controlling this insect. Much good work could be done in young apple orchards during winter by finding and removing the twigs bearing the winter eggs.

The OYSTER-SHELL BARK-LOUSE, *Mytilaspis pomorum,* occurs in several apple orchards, and one report this year stated that a few trees had been killed at Rome, Georgia.

The APPLE-TREE TENT-CATERPILLAR, *Malacosoma americana,* was reported from Washington, Georgia, with specimens, on April 21st, and from caterpillars collected at Hapeville, Georgia, we reared adults which emerged May 8th. This caterpillar is apparently not very abundant in Georgia, though appearing every year.

FOREST AND PECAN TREE INSECTS.

Early in April the newspapers of Georgia began to report a serious invasion of CATERPILLARS in Chatham County near Savannah. These reports said that the caterpillars were present in such numbers that people had to dig ditches around their homes to stop the caterpillars from entering their houses, and that they got on the railroad tracks so thickly that trains could not pass. We immediately investigated these reports and found that the caterpillars in

question were the FOREST TENT-CATERPILLARS, *Malacosoma disstria,* and that they were really present in alarming numbers in the swamps about twelve miles from Savannah. The caterpillars on April 27th had nearly stripped the trees over several acres, leaving only the evergreen species. The following forest trees were attacked: oak, (all species) sweet gum, hickory, willow, and also plum, peach and apple trees. They did not attack the cultivated crops in the gardens, except cabbage which had been eaten a little in one place. It was true that the caterpillars got into houses and caused much discomfort to the inmates; and in one place they got on the railroad track, rendering it slippery so that trains had a hard time getting past.

Many caterpillars were collected and placed in a breeding cage and the following notes obtained: May 8th, caterpillars beginning to pupate; May 24th moths emerging rapidly; May 27th, females depositing eggs.

An interesting occurrence of injury to pecan trees was first brought to our attention April 7th, when we received a letter from Monticello, Georgia, stating that some insect was eating the buds and leaves as fast as they appeared, from a grove of pecans which averaged 10 to 12 feet high. Investigation brought out the fact that the damage was caused by two species of JUNE BUGS, (*Lachnosterna,*) namely, *inversa* and *hirticula.* The adults worked on the trees mainly at night eating the opening buds and entirely preventing the foliage from developing. A method of jarring the tree at night and capturing the beetles on a sheet was suggested as a remedy.

COTTON INSECTS.

Among the COTTON INSECTS several common forms have been present this year, and at least one species not heretofore considered of importance in Georgia.

The COTTON CATERPILLAR, *Alabama argillacea,* was not as abundant as usual, though present in a number of counties in middle and south Georgia. Its late appearance in considerable numbers rendered it almost of no consequence.

The COTTON BOLL WORM, *Heliothis obsoleta,* was also

rather unimportant this year, though we were expecting its appearance in considerable numbers because of the great amount of injury reported in 1904. Remedial measures were not necessary so far as we are aware.

Luperodes brunneus, a NEW COTTON BEETLE, made its appearance in nine places in at least six different counties, in the period between June 20th and July 5th. The counties in which it appeared were rather widely separated, thus rendering the out-break the more remarkable. The beetles appeared in great numbers in all cases, feeding on the leaves, squares, blooms and young bolls of the cotton plants. Their favorite place for feeding was in the opening blooms, from which they would eat the entire center and sometimes the petals. At night they would gather in solid masses on the under side of the leaves and in the squares. It was not uncommon to find as many as one hundred on a single leaf.

Untold damage was reported, the letters received stating that whole fields of fifty acres or more would be devoured in a few weeks if the beetles were not checked. The reports, of course, were sadly exaggerated, but the excitement caused by the appearance of this beetle was intense while it lasted and lead us to investigate. We found it true that some plants were entirely destroyed and sometimes several hundred in a spot, badly injured.. Just where the beetles came from we could not tell. Paris green in dry and wet form was recommended as a remedy and was used in a few places. It was our intention to give the poison a thorough test and a special trip to Vienna was made for the purpose of making an experiment. Upon arrival, however, the beetles had so far disappeared as to render poisoning unnecessary. Further investigation showed that the beetles disappeared in two or three weeks as suddenly as they had formerly appeared.

For want of any accepted common name we have given this beetle the name, "THE NEW COTTON BEETLE," for it is new to the cotton growers of Georgia, and for a time it certainly looked as though the damage caused by them might be serious. The ultimate injury was not great as

the beetles did not spread far from where they first appeared.

The RED SPIDER, *Tetranychus gloveri*, appeared in several cotton fields this year, sometimes covering two or three acres in a field. Dusting with sulphur and spraying with kerosene emulsion was said to give relief in some places.

Among other cotton insects collected in Georgia this year, may be mentioned the SHARP-SHOOTER, *Oncometopia undata*, the COTTON LEAF-BUG, *Calocoris rapidus*, also *Nezara hilaris*, and the COTTON LOUSE, *Aphis gossypii*. None of the last four insects mentioned have caused serious damage, although the cotton louse was abundant as usual.

GRASS, GRAIN AND GARDEN INSECTS.

On July 24th a letter came to the office from Statesboro stating that some WORMS had destroyed a 4-acre field of German millet. This insect proved to be the FALL ARMY-WORM as determined from one half-grown larva. Unfortunately we could not get specimens to rear as the worms all disappeared within a few days after the report. Our correspondent stated that the English sparrows devoured thousands of them, though we believe that they were then entering the ground to pupate. This same worm was observed in a pear and plum orchard in Augusta feeding on the crab-grass. From larvae collected at this point adults were reared September 9th.

The HESSIAN FLY, *Cecidomyia destructor*, is found in all the wheat fields of Georgia. The spring brood appearing in many fields iast spring must have come mainly from the volunteer wheat, as nearly all the wheat in the fall of 1904 came up so late—owing to dry weather—that it was not then infested. Wheat planted early this fall has been found infested to the extent of 96 per cent. Many of our wheat growers are being brought to see the value of late planting and destruction of the volunteer wheat.

Crambus pascuellus, GRASS WEB-WORM, was reared from one larvae collected from a corn field near Atlanta. Apparently the same species of larvae were collected from corn

at Ringgold and Summerville, though we were unsuccessful in rearing adults. This species, we understand from Dr. Chittenden, has never been reported as feeding on corn before. At first it was mistaken for the common SOUTHERN CORN BUD-WORM, *Diabrotica 12-punctata,* which was noticed at several points in Georgia, besides the places mentioned above.

The STRIPED CUCUMBER BEETLE, *Diabrotica vittata,* was reported from Richland on May 2nd, as seriously injuring a field of cantaloupes. It was also reported from and collected at other points in Georgia.

Specimens of the COMMON POTATO-BEETLE, *Doryphora 10-lineata,* came in the mail frequently during April and May.

The HARLEQUIN CABBAGE-BUG, *Murgantia histrionica,* was very abundant on cabbage, collard and turnip during 1905.

On July 18th a crib of CORN containing over two hundred bushels of ear corn was found by Harper Dean, Jr., at Cycloneta, infested with thousands of WEEVILS, *Calandra oryzae.* The destruction of the corn was almost complete when the weevils were discovered. The use of carbon bisulphide at the proper time would have saved many dollars to the owner of this corn. We mention this partly to show what little attention is given to many insects until the damage becomes so apparent that it cannot be overlooked.

Several garden and field crop insects have been more or less common in Georgia this year, but space will not be taken here to mention them.

FINANCES.

Expenditure of the Appropriation of $10,000.00 *for* 1905.

To Appropriation, 1905	$10,000.00
By Salaries as follows:	
Salary of State Entomologist, January 1st to December 31st, at $1,500.00 per annum......	1,500.00
Salary of Asst. Entomologist, January 1st to February 14th, at $1,200.00 per annum	150.00
Salary of Asst. Entomologist, February 14th to December 31st, at $1,000.00 per annum	875.00

Salary of Stenographer, January 1st to December 31st, at $600.00 per annum	600.00
By Expenses as follows:	
Field Assistant, 238 days work at $3.00 per diem	714.00
Wages paid Deputy Inspectors	556.50
Traveling Expenses State Entomologist	431.55
Traveling Expenses Asst. Entomologist	360.28
Traveling Expenses Field Assistant	392.34
Traveling Expenses Deputy Inspectors	395.54
Printing and Engraving	1012.92
Postage	568.50
Telegrams	27.75
Office Supplies and Expenses	362.30
Library (including Agricultural Papers and Journals, binding, etc.).....................	248.43
Laboratory Expenses and Equipment	474.91
Field Work and Experiments	397.96
Express and Freight	65.50
Expenses Board Meetings	39.00
Farmers Institute Work	141.70
Monthly Talk (Paid for Dept. of Agri.)	182.00
	$ 9,496.18
Balance unexpended December 31st, 1905....	503.82
	$10,000.000

NURSERY INSPECTION.

Nursery inspection has received greater attention this year than ever before. Although the number of nurseries and the amount of stock contained is less than in 1904, more time has been spent on the inspection. The fruit growers and nurserymen deserve this attention. In addition to inspecting the stock grown by each nurseryman, the orchards from which they secured buds were inspected in most cases as reported under orchard inspection. This we feel is a great protection to the nurseryman. It has already

served to prevent several nurseries from getting infested.

Inspection of nurseries began August 1st, and the main part of three men's time for four months was devoted to this work; or the equivalent of one year's work for one man, In the largest nurseries the time spent was equal to one man's time for from 7 to 12 days.

160 nurseries have been inspected, and certificates issued to 144 of them. No certificate was issued until the nurseryman was prepared to properly fumigate the stock with hydrocyanic acid gas; and in some places where the stock was grown in what we considered dangerous territory, the fumigation was personally supervised by a member of this Department.

Of the 16 nurseries inspected, and not receiving certificates, 5 were found infested with the San Jose scale, so bad that it could not be cleaned out, while the remainder have not complied with the fumigation requirement.

Certificates were issued to 2 nurserymen, whose stock was found slightly infested, but only after the infested portions were destroyed and the remainder fumigated by a member of our Department.

Total number of trees contained in the 144 nurseries securing certificates are as follows:

Peach, 1 and 2 year old	3,775,450
Peach, June-Buds	2,218,400
Apples	1,300,950
Pear	368,100
Plum	241,100
Cherry	20,700
Grapes	55,000
Pecans (over 1,000,000 are seedlings)	1,378,550
Miscellaneous stock including shade trees, roses figs, mulberries, and small fruits	994,000
Total	10,352,250

In addition to the above list 16 nurseries not receiving certificates contained about 230,000 trees. Several nurseries reported stock early in the season, but when visited

were found out of business. Undoubtedly a considerable number of nurserymen in 1903 and 1904 have gone out of business entirely, not finding it profitable to grow a small lot of stock. The tendency now is to grow more stock or else quit the business entirely. We do not believe that the inspection has been the entire cause for a decrease in the number of nurseries, but rather that it has followed the natural law of supply and demand.

Nurseries outside of Georgia, before selling stock in this State, are required to file a certificate of inspection and also a signed agreement to fumigate according to our recommendations. Up to December 31st, 88 nurserymen outside of Georgia have received certificates for selling in this State. This is an increase of only 1 over last year at same date. For the past two years an average of 11 nurserymen outside of Georgia have received certificates between January 1st and April 1st each year, which number is not included in our reports, as the number given above is for nurserymen who ship during the season of 1905-06.

It is a notable fact that the same number of outside nurserymen are doing business in Georgia, while the total number of Georgia nurserymen has fallen off. This would indicate that Georgia people buy from other States. The Georgia nurseries are more nearly free from San Jose scale than most nurseries in Northern or Eastern States, and some of the Western States. It would seem therefore that the Georgia orchardist would do well to purchase more home-grown stock to avoid danger of getting infested trees.

ORCHARD INSPECTION.

Orchard inspection has been given more attention than in former years. The total number of trees contained in the orchards inspected reach the surprising sum of 1,912,-958, of which all but 1344 were contained in 306 orchards of commercial size. 43 orchards of less than 100 trees contained 1344. We have therefore really inspected a total of 349 orchards of all sizes, containing an average number of 5487 trees. Some individual orchards contained from 25,000

to 100,000 trees. As a matter of interest to show the wonderful predominence of peaches over all other classes of fruit the following table is given.

Orchard trees inspected in 1905 according to class:

Peach trees	1,830,963
Apple trees	50,145
Pear trees	9,210
Plum trees	8,955
Cherry trees	3,000
Miscellaneous	10.685
	1,912,958

The above figures show an increase of about 114 per cent in number of orchards inspected in 1905, compared with number inspected in 1904, and likewise an increase of over 200 per cent over total number of trees inspected in 1904.

With the increased assistance this year we have been able to comply with many requests for orchard inspection which would formerly have been impossible, but even under present conditions we are forced to refuse requests for inspection or at least postpone the visits indefinitely.

Special Feature of Orchard Inspection.

One feature of orchard inspection inaugurated by my esteemed predecessor, is to inspect all orchards from which nurserymen expect to take buds and grafts. By so doing we accomplish the double purpose of inspecting the orchards and protecting the nurseryman against getting infested stock into his nursery. Blanks are sent out early in spring to all nurserymen with a request that they report the orchards which they desire inspected. There is only one objection to this plan, which is that the orchards must in most instances be inspected before the middle of July. This is of course more expensive than regular routine orchard inspection.

During 1905 we received application for inspection of 86 orchards of this class, of which 58 were inspected, while the remaining 28 could not be reached through lack of time and assistance. Of the orchards inspected 5 were found in-

fested and the nurserymen cautioned against getting buds therefrom.

Much more orchard inspection would be of value as many sections have not yet been reached.

EXPERIMENTS.

San Jose scale washes have been tested and the general recommendations for treatment given in Bulletin No. 17. Lime-Sulphur wash still holds the first place as a remedy that can be safely applied. The experiments were conducted mainly at Thomson, Ga., in spring, summer and late fall.

Peach Leaf Curl Disease is generally controlled with Bordeaux and Lime-Sulphur wash. Experiments with different mixtures against leaf curl were made at Adairsville in the spring of 1905. The result has been reported in the Proceedings of the State Horticultural Society for 1905.

The Woolly Aphis of apple is one of our most destructive apple pests. Extensive experiments with insecticides against the underground form were carried out at Morrow and Pittman, Ga. The result of the first year's work is given in the Horticultural Society Report. This work will be taken up again in 1906, and be supplemented by breeding experiments in the laboratory. Harper Dean, Jr.,* will have direct charge of this investigation.

The "cotton wilt" disease has claimed a great part of the time of Mr. A. C. Lewis, Asst. Entomologist, this work being started in a preliminary manner by Wilmon Newell in 1904. Fertilizer tests were made to determine their effect on the wilt disease, but these, we must say, are not encouraging. The principal effort should be directed toward getting a resistant variety of cotton, and this Mr. Lewis is attempting to do by hybridizing. He has now many varieties and hybrids of cotton which will be tested again in 1906. We are prepared to send out a limited number of sample lots of cotton seed of the Jackson-limbless variety. This was grown in the experimental field at Zellobee, Ga.

In co-operation with the U. S. Dept. of Agriculture dem-

*W. V. Reed has taken the place of Harper Dean, Jr.

onstration work in pruning pear trees to control pear blight, was started in November, 1905, and will be continued for at least 3 years. Work has been commenced on an orchard at Thomson, and several at Smithville, and will be taken up at other places. Bulletin No. 18, issued in December, 1905, gives an account of the plans for this work.

Considerable time has been devoted to experiments to determine the proper date to sow wheat to avoid damage from the Hessian Fly. By having special plats of wheat sown at our direction, on certain dates, we have learned from an examination of these fields that the proper date varies considerably between Middle and North Georgia. The result of this investigation is not yet ready to be made known, but when completed it will be of inestimable value to the Georgia wheat growers.

A new Cotton Beetle claimed considerable attention during the latter part of June and early in July. Paris green as a poison was used with success against this pest.

PUBLICATIONS.

Bulletins pertaining to the control of insects have been issued during 1905 as follows:

Bulletin No. 15—"An Inquiry into the cyanide Method of Fumigating Nursery Stock," February 1200 copies.

Bulletin No. 16—"The Cotton Boll Worm"—"Insects Injurious to Corn and Truck Crops," April, 7000 copies.

Bulletin No. 17.—"Peach Insects," October, 7000 copies.

Bulletin No. 18—"Pear Blight Disease and Pear Leaf Blight," December, 8000 copies.

In addition to the regular bulletins circulars have been distributed to nurserymen and others as follows:

February 1—"The Hessian Fly." A timely article telling how the North Georgia wheat growers might deal a severe blow to this destructive insect. Sent to all newspapers in Middle and North Georgia.

February 15—Circular to nurserymen regarding inspection of orchards from which buds would be secured.

July 20—"Regulations of the Board Relative to Fumigation. Sent to all nurserymen in Georgia.

July 24—"Important Information for Nurserymen." Giving a summary of laws of various states. Sent to all nurserymen.

July 31—Circular to Out-of-State Nurserymen, giving Regulation Relative to selling stock in Georgia. Sent to 150 nurserymen in other States.

Other circular letters of minor interest were sent to fruit growers and others at various times. Many articles of timely information concerning insects, such as San Jose scale, Shot-hole borer, New Cotton Beetle, Cotton Caterpillar, Apple Codling Moth, and others have been furnished the Georgia newspapers. Many times the requests for such articles require considerable time for preparation. All such, however, are freely given, whenever possible, as they are of particular value to the Georgia fruit growers and farmers.

BOLL WEEVIL QUARANTINE.

The matter of Boll Weevil quarantine should not be forgotten as the danger to Georgia through invasion by the Boll Weevil becomes yearly more imminent. The Boll Weevil in Louisiana has made an advance of about 50 miles this year, and has gained its way fully half way across that State. Next year it will be liable to reach—if not cross—the Mississippi river. We must continue to enforce the Boll Weevil quarantine measures to avoid the danger of bringing the Boll Weevil into Georgia in shipments of cotton in its various forms. The General Assembly of 1905 very wisely raised the quarantine on threshed wheat and oats, as it is quite fully demonstrated that there is no danger through that source. With the present quarantine laws there is reason to believe that the Boll

Weevil will not reach Georgia except by natural spread. The State Department of Entomology will, however, be on the lookout for its first appearance, and in the event it should appear ahead of the natural spread every known method will be tried to effect its eradication.

During the year a number of cotton fields have been inspected in sections where we have learned through correspondence and otherwise that cotton products have been shipped in from Texas within the years of 1903-04, before the Boll Weevil Quarantine law was passed by the General Assembly of 1904. In the fields inspected we have found no indication of the Bool Weevil.

OFFICE AND CORRESPONDENCE.

The office correspondence is getting to be very heavy. A general idea of the time required for this one feature is shown by the letter book, our letters for the year covering 4088 pages or an average of 13 pages for every day except Sundays. These letters are often of such a nature that considerable study is required before they can be properly answered., Farmers and fruit growers of other States frequently write to our office for advice.

Our mailing list has been increased by nearly 2000 names, numbering now over 5500, which necessitates our sending out large editions of each bulletin, and also greatly increasing the correspondence. Two years ago bulletins were issued in editions of only 2-3000 while now it is necessary to have from 7-8000 to supply the growing demand. Several times during the year it has become necessary to hire extra clerical help and avoid keeping our men from the regular field work which should not be neglected.

The necessity of a good reference library will be understood by all, and this at present is largely supplied by the Bülletins from various state experiment stations. The work of keeping these bulletins properly filed for reference is no small feature in the work connected with our office, And aside from other duties the entomologist must often spend time giving information to fruit growers and others

who come to the office for advice. In fact, it requires more than all the time of one man to properly attend to the duties of the office. Respectfully submitted,

R. I. Smith,
State Entomologist.

PART II.

THE CROP PEST LAW OF GEORGIA.

The following pages contain a correct copy of the crop pest law of Georgia, which is found in the Statutes of Georgia under the caption, "Horticulture and Pomology,"though in reality the department is know officially as the *State Board of Entomology.* The Department of Horticulture and Pomology was first established, as a branch of the Department of Agriculture, by an Act of the Legislature of Georgia approved December 21, 1897, (General Laws 1897, No. 346, pages 180-183.) Under this Act of 1897 the Commissioner of Agriculture was authorized to establish a special department of Horticulture and Pomology, and employ an Entomologist to act as inspector, whose salary and expenses were to be paid out of the appropriation of the Department of Agriculture, said salary and expenses not to exceed Twenty-Five Hundred Dollars ($2500.00) per annum.

In 1898 the Legislature passed an Act creating a State Board of Entomology, with a special appropriation of Twenty-Five Hundred Dollars ($2500.00) thereby making the Board of Entomology entirely distinct from the Department of Agriculture. (General Laws, 1898, No. 78, pages 269-273. By this Act of 1898, the Commissioner of Agriculture, the President of the Georgia State Horticultural Society, and the President of the Georgia State Agricultural Society, were made, *ex-officio,* members of the State Board of Entomology, with the Commissioner of Agriculture as Chairman of the Board. No change has been made in this section of the law since 1898. (See Section 1, of following law.)

By an Act of the Legislature of 1900, approved Dec. 21,

1900, the appropriation for the State Board of Entomology was increased from Twenty-five Hundred ($2500.00) to Five Thousand Dollars ($5000.00) per annum and the Board was authorized to employ such assistants and deputies as were deemed necessary for the proper execution of the provisions of this Act. Under this appropriation of Five Thousand Dollars ($5000.00) per annum the State Board of Entomology worked until 1904 when its increased duties, and the danger to the State of an invasion by the Mexican Cotton Boll Weevil, required a larger appropriation by the State for the proper protection of her Horticultural and Agricultural interests.

The Legislature of 1904 amended the law of 1900 by giving to the State Board of Entomology the sum of Ten Thousand Dollars ($10000.00) per annum for two years—(1905 and 1906). (See Section 3, of following law) and further amended the Act by prescribing additional duties, such as the establishment of a quarantine against any articles from Texas and Louisiana liable to introduce the Mexican boll weevil, an investigation of the "black root" disease of cotton, and other cotton diseases, and attendance whenever possible,at Farmers Institutes. (See General Laws, 1904, No. 620, pages 19-22.)

In 1905 by an Act of the General Assembly, approved August 22, 1905, Section 17 of the Acts of 1904 (Act 1904, page 20) was amended by striking out all of the same and substituting therefor the section appearing in the following pages as Section 17. This change was made in order to allow the shipment of oats and threshed grain from points in Texas and Louisiana, as such articles are not considered liable to introduce the Mexican boll weevil.

The following law comprises therefore all amendments to the original Act of 1898 establishing the State Board of Entomology, and represents Acts of the General Assembly of Georgia relative to this Board, approved Dec. 20, 1898; Dec. 21, 1900; Aug. 13, 1904; and Aug. 22, 1905.

AN ACT

Be it enacted by the General Assembly of Georgia:

(Sections 1 and 2, approved December 20, 1898.)

Section 1. That from and after the passage of this Act, the Commissioner of Agriculture of the State of Georgia, the President of the Georgia State Horticultural Society and the President of the Georgia State Agricultural Society shall, ex-officio, constitute a Board to be known as the State Board of Entomology, of which the Commissioner of Agriculture shall be chairman, which Board shall have full power to enact such rules and regulations governing the inspection, certification, sale, transportation and introduction of trees, shrubs. cuttings, buds, vines, bulbs and roots, that they may deem necessary to prevent the further introduction, increase and dissemination of insect pests and plant diseases.

Organization of State Board of Entomology

Sec. 2. That the State Entomologist appointed by the Commissioner of Agriculture, under the provisions of the Act cited above, approved December 21, 1897, shall act as an inspector under the provisions of this Act, and it shall be the duty of the said Board to promulgate rules and regulations in accordance with this Act for the government of the said Entomologist in the duties devolving upon him in the execution of the provisions of this Act.

Offices of the Board

(Section 3, approved August 13, 1904.)

Sec. 3. There is hereby appropriated out of any funds in the State Treasury not otherwise appropriated, or so much thereof as may be necessary, the sum of ten thousand dollars per annum for two years, said sum to be used as follows: In the employment of an entomologist, whose salary shall not exceed the sum of one thousand five hundred dollars per annum; in the employment of assistant entomologist, whose compensation shall be fixed by the State Board of Entomology; in the payment of traveling expenses, equipment and maintenance of a laboratory, publication of bulletins, and other reports and for defraying all other expenses of the execution of the provisions of this Act.

Appropriation—how expended

(Sections 4 to 14 inclusive, approved December 20, 1898.)

Sec. 4. The Entomologist shall have power under the regulation of the Board of Control, to visit any section of the State where such pests are supposed to exist, and shall determine whether any infested trees or plants are worthy of remedial treatment or shall be destroyed. And he shall immediately report his findings in writing, giving reasons therefo to the owner of the infested plantation, his agents or tenants, and a copy of each report shall also be submitted to the said Board. In case of objections to the findings of the Inspector, an appeal shall be made to the said Board, who shall have the power to summon witnesses and hear testimony on oath, and whose decision shall be final. An appeal must be taken within three days and shall act as a stay of proceedings until it is heard and decided.

Appeal from decision of Entomologist—stay of proceedings

Treatment and destruction of infested trees or plants

Section 5. Upon the findings of the Inspector in any case of infested trees or plants. the treatment prescribed by him shall be executed at once (unless an appeal is taken) under his supervision; cost of material and labor shall be borne by the owner; Provided, however. that in case the trees or plants shall be condemned, they shall be destroyed by the Inspector, and the expense of such action shall be borne by the owner. No compensation shall be allowed for any plants that shall be destroyed.

Hearing before Judge or Ordinary

Sec. 6. In case any person or persons refuse to execute the directions of the Inspector or of the said Board after an appeal, the County Judge, or Ordinary shall. upon complaint filed by the Inspector or any freeholder, cite the person or persons to appear before him within three days notice after being served, and that the said Judge or Ordinary may hear and determine all these cases in vacation; and upon satisfactory evidence, shall cause the prescribed treatment to be executed, and the expense thereof and costs of court shall be collected from the owner or owners of the infected plants.

Unlawful to sell, or transport infested stock

Sec. 7. It shall be unlawful to offer for sale, sell, give away or transport plants. scions, buds, trees, shrubs, vines or other plants, tubers. roots, cuttings, bulbs, known to be infested with dangerously injurious insects or plant diseases. Any person or persons violating this section shall upon conviction thereto be guilty of a misdemeanor.

Authority of Entomologist to enter upon premises

Sec. 8. The said Board of Control, its agents or employees, are hereby empowered with authority to enter upon any premises in discharge of the duties herein prescribed. Any person or persons who shall obstruct or hinder them or their agents in the discharge of these duties shall be deemed gutily of a misdemeanor, and, upon conviction therof, shall be guilty of a misdemeanor.

Power of Board to adopt Rules and Regulations

Sec. 9. The Board shall have the power to also adopt rules and regulations, not inconsistent with the laws and Constitution of this State and the United States, for preventing the introduction of dangerously injurious crop pests from without the State, and for the governing of common carriers in transporting plants liable to harbor such pests to and from the State. and such regulations shall have the force of laws.

Unlawful to ship trees without certificate—punishment

Sec. 10. It shall be unlawful for any grower, nurseryman or corporation to ship within the State of Georgia any trees. shrubs, cuttings. vines, bulbs, roots, without having been previously inspected by either a State or Experimental Station Entomologist or government officer, within twelve months of the date of said shipment, and certificate of inspection to accompany each box or package. Violation of this clause will be considered as a misdemeanor and punishable as such.

Board to designate insects and diseases that constitute infestation

Sec. 11. Be it further enacted, that the members of the said Board, any two of whom shall constitute a quorum in the absence of the third. shall, within 30 days from the passage of this act, draw up and promulgate through the press of the State the rules and regulations necessary to carry into full and complete effect the provisions of this Act, carefully defining what diseases or maladies, both insect and fungus, shall constitute infestation in trees or plants within the meaning and purview hereof.

Sec. 12. Be it further enacted, that any person or persons residing in the State of Georgia, dealing in or handling trees, etc., shall be compelled to have his or their stock inspected annually on or before the 1st of November of each year. If upon such inspection such stock is found to conform to the requirements of the Board of Control, the Inspector shall furnish a certificate to that effect. And any such person or persons making a shipment before the filing of such certificate with the chairman of the Board of Control, shall be guilty of a misdemeanor.

Nurseries to be inspected prior to Nov. 1st. of each year

Sec. 13. Each and every person residing in States or Countries outside of the State of Georgia dealing in or handling trees, plants, cuttings, vines, shrubs, bulbs and roots in this State, shall register his name or firm and file a copy of his or its certificate of inspection furnished by the Entomologist, Fruit Inspector or duly authorized government official of his State or Country, with the Chairman of the Board of Control. Upon failure so to do, said stock shall be liable to confiscation under order of the Inspector.

Shipment of nursery stock from without the State

Sec. 14. When two reputable citizens of any county in Georgia shall notify the Board, from belief, that noxious insects or plant diseases exist in their county, the said Inspector shall be directed to ascertain as speedily as possible by personal investigation, and in such other manner as he may deem expedient, the extent of the infection, and shall act with all due diligence to suppress and eradicate the said pests and give notice to the owner, tenant or agent of such premises to treat such infested plants according to the methods he may prescribe, or destroy them within ten days of such notice, and if after the expiration of such period of ten days the infested plants have not been treated or the treatment has not been properly applied or is not effectual in ridding plants of the pests, the Inspector shall cause such plants to be properly treated or destroyed as in his judgment warrants. The cost of the work shall be covered by execution from the owner of the premises.

Services of Inspector—how secured

Cost of treatment—how collected

(Sections 15 and 16, approved August 13, 1904.)

Sec. 15. It shall be unlawful for any person to knowingly bring into the State of Georgia any living Mexican boll weevil, or any cotton bolls, plants, squares, or seeds containing the adult, pupal, larval, or egg state of said Mexican boll weevil, unless the person shall immediately upon its discovery at once destroy the same or turn over the same to the State Entomologist. Violation of this section shall be punished as provided by section 1039 of the Penal Code of Georgia of 1895.

Unlawful to bring living Mexican Boll Weevil into State

Sec. 16. No cotton-seed, seed cotton, cotton-seed hulls or cotton lint,, in bales or loose, shall be brought into this State from any points in the States of Texas and Louisiana, or from any point in any other State or country wherein the Mexican boll weevil is known to exist, without having attached thereto in a prominent and conspicuous manner a certificate signed by a duly authorized State or government entomologist, stating that such cotton-seed, seed cotton, cotton-seed hulls or cotton lint was grown in, and that the shipment of the same origi-

Quarantine on cotton products from localities where Mexican boll weevil exists

nated in a locality where, by actual inspection by said official or his agent, the Mexican boll weevil was not found to exist. Any steamship, railroad or express company, or any other common carrier, or any firm, person or corporations bringing into this State any of the articles above mentioned without the specified certificate attached, shall be deemed guilty of a misdemeanor. In case any common carrier enumerated violates this section, then the general manager of such common carrier or the captain of such offending vessel shall be deemed guilty, and upon conviction shall be punished as provided by section 1039 of the Penal Code of Georgia of 1895.

Certificate —how obtained

(Section 17, approved August 22, 1905.)

Quarantine against other articles liable to introduce boll weevil

Sec. 17. No corn in the shuck, or shipments of household goods, furniture, machinery, glassware or supplies of any description which are packed or partially packed in or with cotton lint, cotton-seed, seed cotton and cotton seed sacks, or corn in the shuck, shall be shipped into this State from points in Texas or Louisiana, or any other State or country in which the Mexican cotton boll weevil is known to exist, without having attached thereto in a prominent and conspicuous manner the certificate provided for in section 16.

(Sections 18 to 23 inclusive, approved August 13, 1904.)

Transportation companies forbidden to accept uncertified shipments

Sec. 18. Transportation companies shall immediately notify the State Entomologist (Atlanta, Ga.) when, by oversight, negligence or otherwise, any shipment of the nature designated in sections 16 and 17, without a proper certificate attached, shall arrive at any station or wharf in this State, and it shall be his duty to proceed as speedily as possible, by himself or assistant, to investigate such shipment. If, upon investigation, he finds the shipment to be of the nature herein designated, he shall order same removed from this State. Upon failure of the owner or shipper to remove same within forty-eight hours after notice has been sent him by wire, said shipment shall be seized and burned.

Entomologist empowered to inspect all shipments from localities where boll weevil exists

Sec. 19. The State Entomologist and his assistants shall have authority to enter, during reasonable business hours, any depot, warehouse, freight, wharf, transfer, steamship or express office in this State, and shall be allowed full access to all way-bills, books, invoices and bills of lading therein when he or they may deem it necessary to determine the presence or record of any shipments of the nature designated in sections 16 and 17 of this Act. The State Entomologists and his assistants shall have authority to enter at any time, for the purpose of inspecting shipments therein, or for determining the nature of shipments therein, any express car or steamship when same is in transit or lying at dock or depot in charge of any employee or official of the company owning or operating same. Agents and employees of railroads shall be required to open for inspection any car, sealed or unsealed, at any siding, freight-yard or depot in this State when so ordered by the State Entomologist or his assistants. Any person who shall refuse to comply with the instructions of the State Entomologist or his assistants, as herein specified, or who shall offer any hindrance, or shall obstruct the State

Entomologist or his assistants in the discharge of their duties as herein specified, shall be deemed guilty of a misdemeanor, and upon conviction shall be punished as provided by section 1039 of the Penal Code of Georgia of 1895.

Sec. 20. The State Entomologist, himself or assistants, shall have power to enter during ordinary business hours any premises, depot, warehouse, cotton-mill, oil-mill or other building or place in this State where agricultural products are, or are supposed to be, for the purpose of inspecting and determining whether any boll weevils are there present. In case of finding any material therein infested with the boll weevil he shall at once give instructions to the owner, agent or tenant thereof to destroy, fumigate or treat such infested material in such manner as in his judgment he may deem best. But in the event said material shall be ordered destroyed the owner shall be compensated as now provided by law in cases where property is condemned for public use. Failure of the agent, owner or tenant to comply with said directions (unless an appeal be taken as provided for in section 4 of this Act), or the removal of said infested material, or any part thereof, from the premises, shall be deemed a misdemeanor, and shall be punished as provided by section 1039 of the Penal Code of Georgia of 1895.

Procedure if boll weevil is discovered in any shipments

Sec. 21. The State Entomologist, or one of his assistants, is hereby required to attend the Farmers' Institutes, and other State agricultural societies held in this State for the purpose of delivering lectures on injurious insects and plant diseases, for the purpose of disseminating more fully the information obtained by his department among the agricultural classes of the State, whenever it is possible for the State Entomologist or his assistants to attend such meetings.

Entomologist to attend Farmers Institutes, and agricultural societies

Sec. 22. As the cotton interests of this State are menaced by the possible introduction of the boll weevil at any time, and as the boll weevil may at present occur within the State, and that immediate steps may be taken for its detection and extermination, if present, it is considered that an emergency exists, and the sum of two thousand dollars is hereby appropriated out of any funds in the treasury not otherwise appropriated, to become immediately available for executing the provisions of this Act for the period between the date of passage thereof and January 1, 1905.

Special appropriation for 1904

Sec. 23. It shall be the special duty of the State Entomologist to thoroughly investigate the cause of the diseases of the cotton plant known as "wilt" or "black root," and other similar diseases, and make such experiments as in his judgment and discretion may be necessary to find a remedy therefor to be furnished to the farmers of the State, and for other purposes.. The money appropriated by this Act is hereby made immediately available. This Act shall take effect from and after its passage, and all laws and parts of laws in conflict with this Act are hereby repealed.

"Wilt" or "black-root" of cotton.

(Section 24, approved December 20, 1898.)

Sec. 24. It shall be the duty of the Inspector to make a monthly report of his work, both as Entomologist and Inspec-

Monthly and Annual Reports

tor, to the Board of Control as well as the expenditure under this Act, and said Board shall report annually to the Governor of the State. This Act shall take effect from and after its passage, and all laws and parts of laws in conflict with this Act are hereby repealed.

Rules and Regulations

of the

Georgia State Board of Entomology

At the Annual Meeting of the Board held at Macon, Ga., Jan 26th. 1906 the Rules and Regulations of the Board were amended to read as follows:

Rules and Regulations for the Government of the State Entomologist in the Enforcement of the Act of the General Assembly of the State of Georgia Providing for the Control and Eradication of the insect Pests and Fungous Diseases which Threaten the Fruit and other Agricultural Industries of the State, and for the Prevention of the further Introduction of Dangerously Injurious Crop Pests from Without the State.

In pursuance of an Act of the General Assembly of the State of Georgia, approved December 21, 1897, and amended December 20, 1898 and December 21, 1900, and further amended, August 13, 1904, and August 22, 1905, creating a Board of Entomology and authorizing and directing the same to take action for the suppression of certain hereinafter defined injurious insects and fungous diseases, and for the prevention of the further introduction, increase and dissemination of the same, the following rules and regulations are hereby enacted and promulgated:

Pests and diseases constituting infestation

1. In accordance with section 11 of said Act, the following insects and fungous diseases are hereby declared, individually and severally, to constitute infestation in trees and plants; this list to be revised at the will of the Board of Entomology:

The San Jose Scale (Aspidiotus pernicious.)
The New Peach Scale (Diaspis pentagona.)
The Woolly Aphis of Apple (Schizoneura lanigera.)
Black Knot of Plum and Cherry (Plowrightia morbosa.)
The Crown Gall (Dendrophagus globosus.)
The Mexican Cotton Boll Weevil (Anthonomus grandis.)
Rosette of Peach and Plum.
Yellows of Peach.

2. The State Entomologist is hereby charged with the en-

forcement of said Act, and as inspector is directed to locate by personal investigation, correspondence and in such other manner as he may deem best, the above-named pests so far as they may exist in this State, and give proper directions and take such steps in accordance with the above-cited Act as he may deem necessary to control or eradicate the same.

Location of pests—direction for treating same

3. In accordance with Section 5 of the above-cited Act, the State Entomologist is hereby endued with power to condemn and destroy any infested trees, shrubs or other plants that in his judgment are not worthy of remedial treatment, when such infestation is, or is likely to become, a menace to the agricultural interests of any section of the State, or when the owner or owners of infested premises shall refuse or neglect to properly execute the treatment prescribed for him or them.

Power of Entomologist to destroy infested plants, etc.

4. Any trees, shrubs or other plants commonly known as nursery stock, shipped within the State of Georgia, without each box, bundle or package (in each car-load, or less than car-load lot) being plainly labeled with the official Entomologist's certificate to the effect that the contents of same have been inspected and found to meet with the requirements of the Board of Entomology in accordance with Section 10 of the Act cited above, shall be liable to confiscation upon the order of the inspector.

Stock liable to confiscation

5. No trees, shrubs or other plants commonly known as nursery stock shall be sold, delivered or given away within the State of Georgia without being plainly labeled with the certificate of the State Entomologist.

Certificates—when required

6. Persons or firms within the State of Georgia growing for sale trees, cuttings, shrubs, vines or other plants commonly known as nursery stock shall make application to the State Entomologist (Atlanta, Ga.) for inspection and certificate on or before July 1st of each year. Any person, corporation or firm failing to make application to have his or their stock inspected as aforesaid, after receipt of notice of this rule, shall not be permitted to offer for sale in this State any of said stock not inspected; provided that such person, corporation or firm may make written application to the State Board of Entomology to be relieved of his or their default and consequences, and offering to pay any additional expense incurred by the State and its officers by reason of such failure. The Board may upon a proper showing order an inspection of said nursery.

Nurserymen to apply for inspection before July 1st

7. In case some part of a nursery shall be found infested with San Jose scale no certificate shall then be granted; provided, however, that isolated blocks of nursery stock not infested may be considered as separate nurseries and a certificate may be granted covering such nursery stock after all stock in the infested blocks has been destroyed.

Nurseries partially infested—procedure

8 Each and every box, bundle or package of trees, shrubs and other plants commonly known as nursery stock, shipped in car-load lots or less than car-load lots into the State of Georgia from any other state or country shall be plainly labeled with a certificate of inspection furnished by the entomologist, fruit inspector or other duly authorized official in the

state or country in which said stock was grown, and also with the official tag of the Georgia State Board of Entomology hereinafter provided for; said tag to be valid only until July 1st following the date of certificate upon which it is based (See Sections 9 and 13 of the Act cited above.) Such shipments not so labeled shall be liable to confiscation upon the order of the inspector.

Official tag of Board and certificate must be attached to all shipments from without the State

9. Any person or persons residing in states or countries outside of the State of Georgia, dealing in or handling trees, shrubs or other plants in this State or shipping trees shrubs or other plants therein, shall file with the State Entomologist (Atlanta, Ga.) a certified copy (or signed duplicate of original) of the certificate issued by the entomologist, fruit inspector, or other duly authorized official of the State or Country in which said stock was grown. Such certificate for nurseries south of the northern boundry line of North Carolina, Tennessee, and Arkansas must be based upon an inspection made not earlier than July 1st, and for nurseries north of said line upon an inspection made not earlier than June 1st. Said person or persons shall also file with the State Entomologist a signed statement in which said person or persons agree to fumigate with hydrocyanic acid gas all stock shipped into the State of Georgia. Such fumigation shall be in a manner approved by the State Entomologist. Upon receipt and approval of the certificate and statement above-mentioned, the certificate of the Georgia State Board of Entomology will be issued to the applicant without charge, and official tags bearing a fac simile copy of such certificate and the seal of the State Board, will be furnished the applicant at cost of printing viz.,

Official tags—how secured

One hundred tags	60 cents postpaid.
Two hundred tags	85 cents postpaid
Three hundred tags	$1.10 postpaid
Five hundred tags ....'..	$1.35 sent by express collect
One thousand tags	$2.00 sent by express collect

Common carriers forbidden to deliver uncertified stock

10. No transportation company or common carrier shall deliver any box, bundle or package of trees, shrubs or other plants commonly known as nursery stock, shipped from any other State or country to any consignee at any station in the State of Georgia, unless each box, bundle or package is plainly labeled with a certificate of inspection furnished by the official Entomologist of the State or country in which said stock was grown, and also with the official tag of the Georgia State Board of Entomology hereinabove provided for. Such shipments of the nature designated above originating in the State of Georgia, need only have the certificate of the State Entomologist; and unless his certificate is attached to each and every box, bundle or package of trees, etc., they shall not be accepted for transportation.

Duty of Transportation Cos.

11. Transportation companies shall immediately notify the State Entomologist (Atlanta, Ga.) when by oversight, negligence or otherwise, any shipment of uncertified stock is received at any station or wharf in the State, and it shall be his duty to proceed as speedily as possible to investigate and dispose of such stock, as provided for in the Act cited above.

12. All trees, shrubs or other plants commonly known as

All nursery stock must be fumigated

nursery stock (with the exception of conifers and strawberry plants) offered for sale, sold, or given away in this State shall be fumigated with hydrocyanic acid gas by the owner under the direction of the State Entomologist. Each and every nurseryman within this State, growing nursery stock for sale, shall construct and maintain upon his premises an air-tight fumigating house or box and shall maintain such fumigatorium in first-class condition for fumigating nursery stock, between the 1st of August of each year and the 1st day of May following. Said fumigating house or box shall be regularly inspected by the State Entomologist or his assistant in connection with the inspection of nurseries, and the owner of each nursery shall be required to demonstrate to the inspector that he has a practical working knowledge of fumigating methods. Upon failure of the fumigating house or box to pass a satisfactory inspection at the time the nursery is inspected each year, no certificate shall be granted until such fumigatorium has been placed in condition for properly fumigating nursery stock. The expenses of the inspector when making an inspection of such fumigating house after its repair or alteration, shall in all cases be paid by the nurseryman. Upon failure of any nurseryman or dealer in nursery stock to comply with these requirements certificate shall be withheld or cancelled.

Nurserymen required to construct and maintain fumigating house

Inspection of fumigating houses

Official shipping tags

13. Certificate tags of a standard size shall be secured through the State Entomologist, for attaching to all shipments and deliveries of nursery stock within this State. Such tags shall bear the printed seal of the State Board of Entomology and the fac-similie signature of the Entomologist, and shall be furnished to nurserymen holding proper certificates at the schedule of prices given in Regulation 9.

Fumigation of stock from other States

14. On and after January 1st, 1905, all nurserymen or dealers in nursery stock, selling nursery stock within this State, shall be required to thoroughly fumigate, in accordance with the directions furnished them by the State Entomologist, all nursery stock which they may receive from points without the State, before selling or delivering such stock within this State.

Guarantee that all stock is inspected

15. Upon the inspection of any nursery, the owner of said nursery, when ordered to do so by the State Entomologist or by the inspector, shall file with the State Board of Entomology an affidavit to the effect that all nursery stock grown by him, or for him under contract, has been inspected and that the inspectors have been advised of the location of all nursery stock owned, controlled or contracted for by him. Certificate shall be withheld until such affidavit is placed on file.

Publication of bulletins, etc.

16. The State Entomologist is hereby authorized to publish in the form of bulletins, reports, or through the press of the State any matter pertaining to the distribution, life history, habits and treatment of insect pests and fungous diseases, or other matter that may be instructive or aid in the suppression of such pests.

17. The Board of Entomology may appoint temporary deputy inspectors when it appears to be necessary, to assist the Ento-

mologist in the enforcement of the Act cited above, and such deputy inspectors shall have full power to enter on premises and inspect and report to the State Entomologist. **Deputy Inspectors—their power**

18. Appeals from the decision of the Entomologist should be addressed to the Commissioner of Agriculture, (Atlanta, Ga.) who will notify the appellent of the time and place of hearing such appeal. **Appeals—hearing of**

19. The State Entomologist shall be Secretary of the Board and all inquiries relative to the provisions of the above-cited Act and the subject matter of the same should be addressed to him at Capitol Building, (Atlanta, Ga.) **Secretary of Board**

In addition to the above rules, and as further defining the duties of the Entomologist with reference to inspection of nurseries, the State Board of Entomology prescribes the following:

The San Jose Scale shall be considered the paramount pest and inspections shall be made with special reference to this insect. **San Jose Scale—paramount pest**

Nursery stock infested with the New Peach Scale shall be treated in all respects as is stock infested with San Jose scale.

Nursery plants found bearing Crown Gall shall be destroyed under the directions of the State Entomologist and a certificate issued to the owner only after he has given reasonable assurance that such infected plants have been or will be destroyed. **Crown Gall** The same requirement shall apply to nursery trees so badly infested with Woolly Aphis as to have gall formations upon the roots. Plants or trees infested to a lesser degree with this pest shall be treated and allowed to pass inspection. **Woolly Aphis**

Should cases of Rosette or Yellows be found in the vicinity of a nursery all diseased trees must be destroyed before a certificate is given the owner of the nursery. **Rosette and Yellows**

In cases of Black Knot occurring in or adjacent to a nursery, certificate will be withheld until all visibly diseased wood shall have been destroyed. **Black Knot**

Notice—Additional Regulations relative to the quarantine against all articles liable to introduce the Mexican cotton boll weevil, have been adopted and read as follows:

At the regular annual meeting of the Board of Entomology held in Macon, January 26, 1906, the Regulations relative to the quarantine against the Mexican boll weevil were amended to read as follows:

COTTON BOLL WEEVIL REGULATIONS.

Regulation 20. The shipment into the State of Georgia. of cotton lint, (loose, baled. flat or com-

Cotton products from boll weevil sections not allowed to enter State

pressed) cotton seed, seed cotton, hulls, seed-cotton and cotton seed sacks (which have been used) and corn in the shuck, from points in the states of Texas and Louisiana, is hereby forbidden, unless such shipment shall be accompanied by the certificate of a State or Governmental Entomologist to the effect that such shipment originated in a locality where by actual inspection the Mexican cotton boll weevil was not found to exist.

Household goods, furniture, etc.

Reg. 21. Shipments of household goods. furniture, machinery, glassware, or supplies of any description, from the States of Texas and Louisiana shall be admitted into the State of Georgia only when accompanied by a certificate (such certificate to be attached to way-bill) as mentioned in Regulation 20, and provided for by an Act of the Legislature of the State of Georgia, approved August 15, 1904, provided any of the articles listed in Regulation 20 are included in such shipment or used as packing for any part or all of same.

Transportation companies must give notice of receipt of shipments from weevil infested sections.

Reg. 22. Transportation companies shall immediately notify the State Entomologist (Atlanta, Ga.) when, by oversight, negligence or otherwise, any shipments of the nature designated in Regulations 20 and 21 shall arrive at any station or wharf in this State, without a proper certificate or affidavit attached, and it shall be the duty of the Entomologist to proceed as speedily as possible, by himself or his assistants, to investigate such shipments. If, upon investigation, he finds such shipments to be in violation of Regulation 20 or 21, he shall at once order same removed from this State. Upon failure of the owner or shipper to remove said shipment within forty-eight hours after notice has been sent him by wire, said shipment shall be siezed and burned.

Reg. 23. Shipments of the articles quarantined against by Regulations 20 and 21, and by the Acts

of the Legislature of the State of Georgia, approved August 15, 1904, and August 22, 1905, shall be made through this State to points in other states only when in tight closed cars. Such cars shall not be opened at any point while in transit through the State of Georgia.

Quarantined articles may pass through State in closed cars.

Reg. 24. Shipments of nursery stock, fruit and truck into this State, from points in the states of Texas and Louisiana, shall be admitted only when none of the articles mentioned in Regulation 20 are used in packing same, unless such shipment be accompanied by a certificate as mentioned in Regulation 20.

Nursery stock, fruit, etc., how restricted.

Reg. 25. Shipments of live-stock from points in the states of Texas and Louisiana, into the State of Georgia, are hereby absolutely prohibited when any of the articles quarantined against are used as bedding or feed for such live-stock, unless accompanied by the certificate of a State or Governmental Entomologist to the effect that the bedding or feed originated in a locality where, by actual inspection, the Mexican cotton boll weevil was not found to exist.

Live-stock —bedding used.

Available Publications

of

State Board of Entomology

The bulletins of the Georgia State Board of Entomology which are of present practical value, and still available, are mentioned below. (The numbers not mentioned are either out of date or exhausted.) Application for any of these numbers should be addressed to the State Entomologist, Atlanta, Ga.

Bulletin No. 6—The Peach Leaf Curl and its Treatment.

Bulletin No. 9—The Cotton Caterpillar.

Bulletin No. 11—Fumigation of Nursery Stock.

Bulletin No. 12—Mexican Cotton Boll Weevil.

Bulletin No. 13—Some Common Insects Injurious to the Apple.

Bulletin No. 14—Experiments With the San Jose Scale in 1904.

Bulletin No. 15—Cyanide Method of Fumigating Nursery Stock.

Bulletin No. 16—Cotton Boll Worm and Insects Injurious to Corn and Truck Crops.

Bulletin No. 17—Peach Insects. A treatise on the important Peach Insects in Georgia.

Bulletin No. 18—Pear Blight Disease in Georgia, and Pear Leaf Blight.

Bulletin No. 19—Insecticides and Fungicides—When and How to Spray.

GEORGIA
State Board of Entomology

BULLETIN No. 21.—OCTOBER, 1906.

Spraying to Control the San Jose Scale

BY

R. I. SMITH, State Entomologist.

CAPITOL BUILDING Atlanta, Ga.

GEORGIA

State Board of Entomology

BULLETIN No. 21.—OCTOBER, 1906.

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BY

R. I. SMITH, State Entomologist.

CAPITOL BUILDING

Atlanta, Ga.

ATLANTA, GA.:
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1906.

GEORGIA STATE BOARD OF ENTOMOLOGY.

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Ex-Officio Mmeber.

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Ex-Officio Member.

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W. W. CHASE,

Deputy Inspector, Atlanta,

Fig. 1.—Peachtree, with top, killed by the scale. **Fig. 2.**—Peach twig, moderately infested, showing male and female scale. **Fig. 3.**—Peach limb, badly infested with scale. **Fig. 2** enlarged four times ; **Fig. 3** enlarged twice. After A. L. Quaintance, U. S. Dept. of Agr., Yearbook 1905.

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BULLETIN

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SPRAYING TO CONTROL THE SAN JOSE SCALE

SUMMARY.

Boiled lime-sulphur wash is recommended as a remedy for the San Jose scale.

Salt in the wash does not appear to be necessary or desirable.

Soluble Oil Sprays should be used cautiously. Do not depend entirely on these preparations without first giving them thorough test on a small number of trees.

Badly infested orchards should be sprayed twice; once in fall and again the following spring.

Orchards which cannot be sprayed twice should be given one thorough spring spraying.

Large orchards will have to be partly sprayed in fall or winter. In such cases spray the least infested portion in fall or winter, and the worst infested portions of the orchard in spring. Or better yet, spray the worst infested portions both fall and spring.

Convenient, serviceable boiling arrangement must be provided for boiling lime-sulphur wash.

Steam boiling outfits are most desirable when considerable quantities of lime-sulphur wash must be made.

Iron kettles may be used for boiling small quantities of lime-sulphur wash. When such kettles are used set them in brick arch as shown in Fig. 4.

Spray pumps capable of giving sufficient power to throw a strong spray should always be used. Whenever more than a few trees are

to be sprayed, it does not pay to attempt to use small, cheap spray pumps.

Thoroughness in spraying is necessary in order to secure satisfactory results. This rule applies no matter what mixture or solution is employed for spraying the trees.

The lime used in preparing lime-sulphur wash should be a calcium lime instead of a magnesia lime. The latter is not desirable. See discussion of grades of lime on page 206.

Sulphur may be purchased in different forms, but the grades most highly recommended are "flour" or "flowers" of sulphur.

Self-boiled lime-sulphur washes may sometimes be used with success, but they are not recommended for general use on account of the extra expense involved.

The addition of tar, potash lye, copperas, bluestone, or any other substance to the regular lime-sulphur wash, does not appear to be necessary or desirable on account of making the mixture more costly.

Experiments conducted by individuals often result in valuable discoveries. Fruit growers are urged to make experiments with any remedy for the San Jose scale, but to do so on a conservative basis.

The San Jose scale may be kept in control if all who have infested orchards will apply the remedies recommended. It is better to spray orchards from one end to the other when only a few trees ar actually found infested, and thereby prevent injury, rather than to delay the spraying until the orchards become badly infested by the scale.

SPRAYING TO CONTROL THE SAN JOSE SCALE

BY

R. I. SMITH.

INTRODUCTION.

Spraying to control the San Jose scale* is now generally accepted by nearly all fruit growers as the most efficient means of fighting this pest. Spraying is no longer in an experimental stage. No one questions the necessity and few question the value of spraying. The only bone of contention among fruit growers and entomologists concerning the operation of spraying to control this scale, lies in the question of what to use, and when and how to make the application. Even on this score most entomologists are agreed on the best known remedy, but some fruit growers are prone to look for something better or at least different from the mixtures most commonly advocated.

Entomologists and others who make official recommendations for the guidance of fruit growers, are compelled to be conservative; to think carefully and weigh all sides of the question. Frequently they may be almost compelled to recommend some mixture that does not meet the approval of all fruit growers. Such is the situation when recommending lime and sulphur wash for spraying to control the San Jose Scale. The writer appreciates his position as keenly as do those who read these lines. Lime and sulphur wash is not pleasant to handle. It is not strange that fruit growers dislike to undertake the work of spraying with it. Still in view of all this opposition we shall still recommend lime and sulphur until something equally efficient, or more so, has been discovered and proven.

Georgia fruit growers in many parts of the State, have, during the past few years, demonstrated beyond question the value of lime and sulphur as a remedy for the San Jose Scale. Hundreds

*(Bulletin No. 17, on Peach Insects, gives a full description, and Life History of the SAN JOSE SCALE, and may be obtained by applying to the State Entomologist, Atlanta, Ga.)

of orchards that have been sprayed each winter for the past four or five years, silently testify to the value of the boiled lime and sulphur wash. Orchards which four years ago were nearly ruined by scale, are now practically free and doing apparently as well as orchards not infested by this pest. Of course this spraying has cost money; but consider the result!

Purpose of this Bulletin.

This bulletin is written, and will be given a wide circulation in Georgia, for the purpose of placing reliable information in the hands of all fruit growers. The recommendations made herein are given only after mature consideration and far-reaching observation. Mention is made herein of the soluble oil preparations that are now being sold and recommended by the manufacturers and also by some prominent fruit growers. The writer does not desire to be classed as one prejudiced against these new preparations, but rather as one who desires to give them an opportunity for proving their merit. Fruit growers cannot afford to risk too much; their orchards are too valuable. When the soluble oil preparations have been used long enough to show conclusively that they are equal to lime and sulphur wash —as a destroyer of San Jose scale—then he will be as ready as any one to recommend them to the Georgia fruit growers.

LIME-SULPHUR WASH

versus

LIME-SULPHUR-SALT WASH.

Experiments conducted in 1903, 1904 and 1905, by the State Board of Entomology have shown that lime and sulphur wash, without salt, will prove practically as efficient as lime, salt and sulphur wash. Applications of these two mixtures have been made side by side for the purpose of comparison. The results have been about equal, or so nearly so that neither one seemed to have any decided advantage. In some instances lime and sulphur alone has proved superior to the mixture with salt added, but in other cases the reverse was true. The difference in results obtained was generally due and traceable to the manner in which the mixtures were prepared. Perhaps nothing used for spraying purposes is liable to greater variation than the lime and sulphur mixtures. This is due largely to difference in grades of lime, difference in grades of sulphur, and particularly

to the matter of boiling the mixtures. Whether one or the other mixture is used the matter of proper preparation is one of prime importance. This will be discussed with the directions for preparing the mixtures in the following pages.

While we recommend lime and sulphur without salt we will give the formula including salt in case some growers desire to continue its use. (See page 206.)

Lime and Sulphur Wash.

Formula

Lime	20 pounds.
Sulphur	16 pounds.
Water to make	50 gallons.

Boil from 40 minutes to 1 hour.

Directions for Preparing.—Mix the sulphur into a thin paste, using only enough water to break up all the lumps. Place about 15 gallons of water in a kettle, or boiling tank, or vat, if steam is employed, and heat to the boiling point. Add the sulphur paste to the boiling water and mix thoroughly. Next add the stone lime—which should be previously weighed out and ready for use—and while the lime is slaking stir often enough to keep the lime and sulphur well mixed. In this way the entire heat of the slaking lime combined with the heat of the boiling water will dissolve much of the sulphur. *As the sulphur goes into solution a rich brick-red color will appear.* While the lime is slaking water may have to be added to prevent boiling over. Where steam is employed it will have to be turned off until the lime is partly slaked. An excess of water, more than 15 or 20 gallons at the most, is not desirable. After the lime is slaked continue the boiling for from forty minutes to one hour, or more if necessary to get the sulphur well dissolved.

Time Required for Boiling.—Concerning the time required for boiling, no definite rule can be given. The operator must be guided by the condition of the mixture. *When properly boiled the lime and sulphur wash will be a dirty orange red color with slightly greenish cast, and no sign of the light yellow sulphur color will be evident.* This may be accepted as an unvarying rule and the time of boiling regulated accordingly. By using steam a mixture of the proper color may often be secured after 25 or 30 minutes boiling, but in kettles over a wood fire the boiling must often be continued for one hour or more.

When the mixture is boiled until it assumes the correct color

it is ready to be diluted to 50 gallons. The dilution may be made with cold water, but warm water is preferable if it can be secured. *When the mixture is diluted it should still retain the orange red color. This is the crucial test. If the yellow color appears in the diluted mixture the concentrated solution is not boiled sufficiently.*

By carefully adhering to the above rules many failures in spraying may be avoided.

Lime-Sulphur and Salt Wash.

Formula

Lime	20 pounds.
Sulphur	16 pounds.
Salt	10 pounds.
Water to make	50 gallons.

Boil from 40 minutes to 1 hour.

Directions.—This mixture is prepared exactly like the lime and sulphur (see page 205) except that the salt should be added after the lime is through slaking.

Concerning the Grade of Lime to be Used.

According to experiments recently conducted by the Virginia Experiment Station,* the calcium limes should always be employed. The magnesia limes do not unite as well with the sulphur and sometimes failure of lime and sulphur wash may be traced directly to the employment of magnesia lime. The fruit grower should insist on getting a good grade of calcium lime when purchaisng lime to use in making lime and sulphur wash. Lime that will slake down completely, instead of leaving lumps that will not break up, should be used if possible. Fresh unslaked lime is also necessary. Air slaked lime does not unite as completely with the sulphur, and should not therefore be employed. If necessary to use lime that is partly air-slaked an increased amount, over the 20 pounds recommended, should be used. Thirty or forty pounds of lime will not hurt the resulting mixture, but when fresh unslaked lime is at hand, twenty pounds to sixteen pounds of sulphur and fifty gallons of water is sufficient.

Grades of Sulphur.

Sulphur is sold in different ways and under different names,

*A bulletin recently issued by the Virginia Experiment Station. Blacksburg, Va., (Bul. No. 1, New Ser.. Lime-Sulphur Wash Studies, 1904 to 1906) gives result of recent experiments with lime of various grades, and may be secured on application.

but the forms most commonly used by fruit growers are, *flour of sulphur,* and *flowers of sulphur.* The latter is really sublimed sulphur, or the sulphur that crystallizes on the sides of the chambers in which the sulphur fumes are caught, while the former is the sulphur that condenses or melts from the sulphur fumes and is caught in molds where it hardens and is afterward ground to a fine powder. Flowers of sulphur are scraped from the walls of the sulphur chambers and do not require any grinding. Flour of sulphur is made by grinding the sulphur, known as brimstone, that is caught in the molds. The two grades of sulphur are practically the same, chemically, only that the "flowers" are a little lighter and more finely divided than the "flours."

For making lime and sulphur wash either "flour" or "flowers" of sulphur may be used. The flour of sulphur is usually cheaper than the flowers of sulphur and for that reason it is preferable.

Our experiments have shown that flour of sulphur is equal in value, pound for pound, with flowers of sulphur, for making lime and sulphur wash, hence we see no reason why fruit growers should pay the extra price charged for flowers of sulphur when the cheaper grade is just as valuable.

Crystalline sulphur, or a sulphur ore sold under the name crystalline sulphur, has been used to some extent in Georgia during the past two seasons. Analysis shows this sulphur to be nearly as pure as either flour or flowers of sulphur, but on account of coming in lumps the crystalline sulphur is not desirable for making lime and sulphur wash. The lumps are often hard to break up and it requires a long period of boiling to dissolve even the small lumps. If the crystalline sulphur could be ground to a fine powder it would no doubt be valuable, but as now sold fruit growers are cautioned against trying to make it take the place of the ordinary sulphur.

Sulphur should be in such a condition as to make it easily dissolved by boiling, and any grade of sulphur that will not dissolve in the usual time, as recommended, should not be used on account of its causing additional expense.

Disadvantage of Using Salt.

As already mentioned, salt does not seem to be necessary, but some fruit growers who have had good results where salt has been used will prefer to continue its use. There are, however, some disadvantages that cannot be overcome. One is, the

tendency of salt to cause iron and other metals to rust. This is one reason why salt should be discarded if possible. The steam pipes around the boiling tank, and the iron portions of the spray pumps, as well as the iron on wagons, rusts badly when covered with lime-sulphur and salt wash. Lime and sulphur wash alone is bad enough, but the addition of salt makes even more trouble. Then the matter of expense, not only for the salt itself, but the handling, should not be overlooked. Further than this, a few peach growers have been led to believe that the mixture of lime, sulphur and salt was the cause of the death of small twigs on sprayed trees, and they have believed the salt was largely responsible for the injury. Whether this last assertion is true or not I am not prepared to say. Everything considered, however, salt seems to be undesirable and unnecessary.

LIME-SULPHUR WASH WITHOUT BOILING.

There has always been considerable talk of making a wash containing lime and sulphur without the necessity of boiling, which is an expensive operation. Fruit growers often ask the question: Why is it that we cannot use an excess of lime or else use caustic potash or soda to help dissolve the sulphur and thus save this expense of boiling? In reply to that question we can honestly state that such a thing is possible. At the same time we must state that it does not appear to be an economical plan.

In 1904, the State Board of Entomology made a series of experiments at Myrtle, Ga., with the use of various mixtures containing lime, sulphur, salt, tar, potash or caustic soda, etc. The result of those experiments was reported in Bulletin No. 14, in 1904. At that time there was published a formula for a self-boiled lime, sulphur and caustic soda wash. The experiment at Myrtle had shown that such a wash could be used when desirable to make up a small quantity of lime and sulphur wash, but that it did not seem worthy of general application.

For the benefit of fruit growers who have only a few scale infested trees the following formula is copied from our Bulletin No. 14:

The Lime-Sulphur-Soda Wash.

Formula

Lime ----------------------	16 pounds.
Sulphur -------------------	8 pounds.
Commercial caustic soda ---	8 pounds.
Water ---------------------	50 gallons.

Mix the sulphur into a thick paste with a small amount of BOILING HOT water. Then add the caustic soda slowly, (do not dissolve the soda in water) keeping the mixture thoroughly stirred. A brick-red color will appear almost at once. Continue the addition of the soda, and continue stirring, adding small amounts of hot water as may be necessary to prevent the mixture getting too thick. The soda should dissolve all of the sulphur in a few minutes, producing a clear, deep red liquid. Unless the liquid is entirely clear, with no particles of undissolved sulphur remaining, the mixture must be heated until all sulphur is dissolved. IT IS ABSOLUTELY IMPERATIVE THAT ALL SULPHUR BE DISSOLVED AND A CLEAR LIQUID OBTAINED, BEFORE THE LIME IS ADDED. To the clear liquid described, add the stone lime, previously weighed out, and while it is slaking keep well stirred. The completed preparation will have the familiar yellowish-green color characteristic of the lime-sulphur preparations. Dilute with cold water to the desired point and spray at once.

We cannot recommend the above formula as highly as the boiled lime and sulphur wash. Whenever the self-boiled wash is used on trees badly infested by scale it will be necessary to make two applications, one in late fall and one in early spring. By increasing the amounts of each ingredient used to each 50 gallons of water, a wash equal to lime and sulphur would be obtained, but the expense of the mixture would then debar its use. Further than this, it requires more care to make the self-boiled mixture, and in practice it would be found that the ordinary negro laborer would not be able to secure perfect results.

Lime-Sulphur and Potassium Sulphide Mixture.*

Formula

Lime ----------------------	20 pounds.
Potassium Sulphide --------	20 pounds.
Water (to make) -----------	40 gallons.

This formlula is highly recommended by Drs. Britton and Walden of the Conn. Experiment Station, for use in spraying a few small trees and shrubs. They state that it is hardly practicable for spraying large trees, on account of its expensiveness.

Directions for Preparing.—Place the weighed potassium sulphide in a half-barrel and add three or four gallons of water.

*Conn. Exp. Station Bull. 146. (Britton & Walden.)

Stir occasionally. Place the lime in a barrel and slake carefully, the same as for a boiled mixture. When the potassium sulphide has all dissolved add it to the slaked lime, with water to make about one-third the required volume. Then strain the mixture into the pump barrel, dilute to make the right proportion and apply to the trees.

OTHER LIME AND SULPHUR PREPARATIONS.

Doubtless some fruit growers will want to know about other methods of using lime and sulphur wash than the ones already given. Many different formulas have been tested, some calling for the addition of potash lye, coal tar, bluestone, copperas, etc., combining one, or two or three of these extra ingredients with the lime and sulphur wash. Experience has shown in the majority of instances that none of these extra ingredients are necessary when making a wash to destroy the San Jose scale. The addition of any substance adds to the expensiveness of the wash without resulting in a correspondingly better result. It does not seem to the writer advisable or desirable to recommend any other formulas than the ones already given. It would be possible to record several instances of how certain fruit growers have been disappointed by attempting to secure good results from using formulas widely differing from those generally recommended. Experiments of this kind are often expensive. Fruit growers should go slow in trying preparations that have not been tested.

Value of Experimental Work.

No one can doubt the value of repeated experiments in attempting to control the San Jose scale or other insects. These experiments, however, are frequently costly and cannot easily be borne by individual orchardists. The State Experiment Stations and State Boards of Entomology and other similar institutions are established and supported by the State or Federal Government for the purpose of taking these burdens off of the shoulders of the individual. In Georgia the work of finding a remedy for the San Jose scale is placed by the State in the hands of the State Board of Entomology. This body has done and will continue to do, all in their power to control the San Jose scale. Now under these conditions it seems almost unnecessary to say that orchardists would often save time and expense by following the directions of our Board, or some other similar Board or Commission.

Experiments by individuals often result in valuable discoveries, but these experiments should be made with care, and operated on a conservative basis.

The above statement has been called forth by the fact that several orchardists in Georgia, during the season of 1905-06, attempted to use new and comparatively untested preparations to destroy the San Jose scale with a result that their orchards are now in a precarious condition. Others, more fortunate, have had better results. As a general rule, however, orchardists would do well to go slow in the matter of individual experiments. This advice is given with a full knowledge of conditions as they exist at the present time. Nothing is gained by arriving at hasty conclusions—too often guess work—and for that reason principally we still recommend the straight boiled lime and sulphur wash.

SOLUBLE OIL PREPARATIONS.

As stated in the introductory paragraphs of this bulletin we desire to make mention of the soluble oil sprays now recommended, by the manufacturers and by a few entomologists, as a remedy for the San Jose scale. It may be stated at the outset that we *do not recommend* fruit growers in Georgia to attempt to use the *soluble oils in place of lime-sulphur wash,* at least *until the oil sprays have been given further trial.* While not recommending the oil preparations for general use we do urge fruit growers who are dissatisfied with the lime-sulphur wash to test the oil sprays on small blocks of badly infested trees. Only in this way can the true value of the remedy be determined. In the following paragraphs the result of the experiments and observations made by members of the State Board of Entomology will be given. These results are written entirely without prejudice, or with any intention of seeming to belittle the true value of the soluble oil sprays. We simply desire to let the Georgia fruit growers know the results so far obtained by the use of soluble oil sprays as they appear to the unprejudiced observer.

The order in which the following preparations are mentioned does not mean that preference is given to any one in particular. The comparative value of the soluble oil sprays is not indicated by the order in which they are mentioned.

Scalecide (Pratt's).

Scalecide is manufactured by the B. G. Pratt Company, 11 Broadway, N. Y., and recommended by them to kill San Jose scale by using a 5 per cent solution. According to the words of the above company, which appear in one of their circulars, Scalecide is, "a petroleum oil that will mix instantly with cold water in any proportion, and will not separate out in days or weeks, except by boiling or freezing it out." They state further, "this we accomplish by breaking up the oil globule (the nearest approach to a pure petroleum soap), which, when mixed with water, spreads out in a very thin but perfect sheet of oil."

Scalecide is recommended by the manufacturers to be used at a strength of 1 part Scalecide to 20 parts water. The solution

is prepared for spraying by simply adding one gallon of Scalecide to the twenty gallons of water. This is a very simple process. The solution does not require agitation after the first thorough mixing.

On November 23rd and 24th, 1905, Scalecide was used in our experimental spraying at Thomson, Ga. The solution was tested at strengths varying from 1 part Scalecide and 5 parts water to 1 part Scalecide and 20 parts water. Without going into the details of the experiment the results obtained showed conclusively that the solution ought to be used at a strength greater than that recommended by the manufacturers. Where we used Scalecide at 1 to 5, and 1 to 10, we killed practically all the scale, but at the strength of 1 to 15, we were unable to kill all, or nearly all of the scale, and at 1 to 20 the solution did not kill over 50 or 60 per cent of the scale. As this experiment represented the result of spraying only a small number of trees, we did not care to depend fully on that result alone. We therefore made special examination of orchards at Fort Valley, Elberta (14 miles south of Macon), and Warthen, Ga. At each of these places extensive orchards were sprayed during the season of 1905-06. The result of our observations showed the following:

On April 11th, at Fort Valley, the writer personally examined two extensive orchards sprayed with Scalecide. The spraying was done during January and February. Examination showed that the Scalecide (which had then been on about two months) had killed a large per cent of the scale in the Hale orchard but in the other orchard the spraying had not been successful. Whether this was due entirely to poor spraying, or not, I was unable to determine. In the orchard where it was apparent that a large per cent of the scale had been killed, it was found by comparison with an adjoining block sprayed with lime-sulphur wash that the latter treatment had been even more successful. These sprayings were made on peach trees.

The Hale orchard at Fort Valley was again inspected by the writer on August 28, 1906. At that time the sprayed trees were nearly free from scale, comparing well with the trees sprayed with the lime-sulphur wash. This report alone, would indicate that the Scalecide treatment might be recommended, but note the result of the other examinations:

At Warthen, two orchards sprayed in January 1906, were examined by W. W. Chase, our deputy inspector. He reports that examination of one orchard at Warthen, which had been

sprayed two weeks before the date of examination, January 17, 1906, showed fully 50 per cent, by actual count, of the scale alive. The other orchard on that date had been sprayed only two days. On June 13th, Mr. Chase again inspected these orchards and reported that the treatment appeared to be quite effective, as very few young scale were found and only a small per cent of the old scale were apparently alive. Why he found this condition in June it is hard to understand unless he happened to make the examination at a time when very few young scale were moving. On August 30th. Mr. Chase made a third examination of the orchards at Warthen. His report was as follows:

"Mr. Duggan's and Mr. Gilmore's orchards were examined again on this date, (Aug. 30, 1906). In Mr. Gilmore's orchard the live scale were very abundant, most of the young wood of the season's growth being infested. Mr. Duggan's orchard was never as badly infested as the other, but here, too, much live scale was found in the infested sections. The results at this time appear to be very unsatisfactory."

In Mr. Gilmore's orchard a few trees, sprayed especially for the purpose of examination, the spraying being done as thoroughly as possible, proved to be, at the August 30th examination, as badly infested as any portion of the orchard. This showed conclusively that the poor result from the use of Scalecide could not be laid to poor or improper spraying.

At Elberta the orchards of the Elberta Fruit Company were sprayed with Scalecide during December 1905, and February 1906. One two-year old orchard was sprayed twice, each time thoroughly, according to the statement of the manager, and on April 21, 1906, when examined by the writer, was found to have fully 50 per cent of the scale alive. These were small trees that could easily be covered with the spray.

The above reports show such contradictory results, that we are compelled to warn fruit growers against depending too thoroughly on this treatment. We know instances where the Scalecide treatment has been pronounced, by fruit growers, as thoroughly successful. Our experiments, backed by the result of observations made in large orchards, would indicate that satisfactory results may not be expected in the majority of cases.

"Target Brand" Scale Destroyer.

A soluble oil spray sold by the American Horticultural Distributing Co., Martinsburg, W. Va., under the above title, has

been used by several Georgia orchardists during the past season. The Target Brand Spray is spoken of by the manufacturers in their advertisement in the following words: "Target Brand Scale Destroyer is a soluble mineral oil. Not a drop of crude oil used in it. When diluted it has a most agreeable odor and has the appearance of milk. . . . It has no caustic action and hence cannot injure hands, body, clothing or spraying apparatus." The spray is recommended to be used at the rate of 1 part Target Brand to 20 parts of water.

Experiments with Target Brand Scale Destroyer were made by the State Board of Entomology in November 1905, at Thomson, Ga. In our experiments we tested the spray at strengths of 1 to 5, 1 to 10, 1 to 15 and 1 to 20. These tests were made at the same time and in the same manner as tests with Scalecide solution mentioned above. The result of these experiments show very little difference between Scalecide and Target Brand so far as their effect upon the scale was concerned.

In order to make our results more conclusive, we made special effort to examine large orchards in which the Target Brand spray was used on an extensive scale. Our observations were made in orchards at Columbus and Fort Valley. The result of these observations is given below.

At Columbus an orchard of about 20,000 trees, owned by John Dozier Pou, was sprayed on several dates between December 15th, 1905 and February 15th, 1906. Some portions of the orchard were given two sprayings, one in December and one in February. Mr. Pou's orchard has been examined on four different occasions during the past spring and summer by Mr. A. C. Lewis, assistant entomologist. Twigs from the sprayed trees have been sent by Mr. Pou to our office for examination. The writer has also made a personal examination of the orchard at Columbus in company with Mr. Pou and Mr. Lewis. The result of all these examinations has shown that the Target Brand Scale Destroyer has not been successful in controlling the scale. The following notes by Mr. Lewis will serve to illustrate the condition of the orchard, showing that the scale was not properly controlled by the Target Brand Spray. February 3rd, Mr. Lewis reported as follows:

"I examined a number of trees in different parts of the different blocks. Counts were made on from four to six trees in each separate block and the results obtained represent the average condition of the orchard. On unsprayed trees from 50

to 60 per cent of the scale were alive, taking both young and old scale into the count. Most of the young scale were alive, that is, those in the half-grown stage. Trees sprayed twice, once in December 1905 and again in February 1906, showed 79 to 80 per cent of the scale dead. Compared with the unsprayed trees this result shows that the Target Brand Scale Destroyer killed only about 60 or 70 per cent of the live scale."

This report represents the condition of the orchard February 3rd, 1906.

In April, when the next examination was made, count of the dead and live scale would have shown a much less satisfactory result. A portion of this orchard was given a summer treatment in June, as the scale was increasing so rapidly that it was feared many of the trees would die before the end of the season.

At Fort Valley the writer has visited orchards sprayed under direction of the manager of the United Fruit Company, and an orchard owned by G. H. English, both of which were thoroughly treated with this spray. Result of the treatment in the United Fruit Company's orchard was very unsatisfactory. The first examination was made April 9th, 1906. The average result of this examination showed that not over 60 or 70 per cent of the scale had been killed. Examination of some individual trees seemed to indicate that the spray had done good work, but on other trees there was practically no indication that the scale had been destroyed by any treatment. The writer made a second examination of the United Fruit Company's orchard on August 28th. Special examination was made of one two-year old peach orchard which had been severely pruned back last winter and the trees thoroughly sprayed with Target Brand Scale Destroyer. Nearly all the trees in this orchard showed much live scale on the new growth. In fact, some limbs were almost encrusted for a distance of 10 to 15 inches. As these trees were very small there was no reason why the spraying should not have been thoroughly done. Examination of a four-year old orchard gave practically the same results. One row of trees in this orchard had been given two sprayings and even on those trees the scale were abundant on twigs of this year's growth.

On August 28th the writer also visited Mr. G. H. English's orchard which had been sprayed with Target Brand. This orchard was not as badly infested as the orchard of the United Fruit Company, and the result of the spraying appeared to be much better. It was evident from these examinations that the results of spraying with this solution are apt to be very contradictory and very unsatisfactory.

Kil-O-Scale.

Kil-o-Scale, another oil preparation, manufactured by the Thomsen Chemical Co., Baltimore, Md., and sold by the Griffith-Turner Co., Baltimore, Md., is supposed to be much like the two preparations mentioned above. We made an experiment to determine the value of this spray in comparison with Scalecide and Target Brand Destroyer. Kil-o-Scale was tested at Thomson, Ga., March 2nd, 1905. The strength used was 1 to 20, as recommended by the manufacturers. On April 8th the examination showed that about 50 per cent of the scale were alive. May 25th, the time the second examination was made, the young scale were beginning to move and the sprayed trees appeared to be almost as badly infested as the unsprayed trees. Later examination showed that the sprayed trees were fully as badly infested as the unsprayed trees.

In justice to the manufacturers we must say that we have been advised that they have improved the Kil-o-Scale preparation since we made this experiment. We understand, however, that the Kil-o-Scale is a preparation much like Scalecide and Target Brand Scale Destroyer, and we think that orchardists should make careful test of the value of all these preparations before using them for spraying entire orchards.

The soluble oil preparations as usually recommended for use, at a strength of 1 part of oil to 20 parts of water, have not, in my opinion fulfilled the claims made for them by the manufacturers. It is quite evident that these soluble oils might be used in more concentrated form and made to give good results. The expense of the wash when used at a strength sufficient to kill scale would, however, in most instances, debar its use.

We realize that the soluble oil sprays are much more convenient to handle than the lime-sulphur wash, and that they would gladly be accepted by fruit growers if good results could be obtained from their use. It is our intention to give the soluble oil sprays a further test this fall and next spring, and if we get favorable results we shall not hesitate to make the Georgia fruit growers aware of the fact.

Other soluble oil sprays, aside from the ones mentioned above, are on the market, but as we have not had an opportunity of testing them we have nothing to say in regard to their being used except, as already mentioned, we think they should first be tested in an experimental way.

PREPARATION AND APPLICATION OF LIME AND SULPHUR WASH.

Suitable boiling outfits for making lime and sulphur wash must be provided. The form and capacity of the boiling outfit will depend largely on the size of the orchard that is to be sprayed. Orchardists who intend to spray over five thousand trees will usually find it most convenient and economical to provide steam boiling outfits for boiling lime and sulphur wash with steam. Mixture sufficient for spraying small orchards of from one to five thousand trees may be made economically in iron kettles set in a brick or stone arch, as well illustrated in Fig. 1. In case only a few hundred trees have to be sprayed, the mixture for these trees can be made in open iron kettles of any desired capacity. The individual must judge which boiling outfit will be most practicable.

The location of boiling outfits must be given careful attention. In each orchard it is desirable to locate the boiling outfit in such a position that the spray mixture will not have to be hauled for long distances. Special attention must be given to the water supply, which can be obtained from wells or creeks.

For the information of orchardists who will have to prepare boiling outfits, figures and illustrations are given herewith showing how boiling plants may be constructed.

The proper application of lime and sulphur wash is absolutely necessary in order to secure satisfactory results. For applying this wash good, serviceable spray pumps with the necessary hose, extension rods and nozzles must be provided.

A few trees may be readily sprayed by the use of a bucket pump (Fig. 8) equipped with necessary length of hose and suitable nozzle. Such an outfit would not be economical for spraying a large number of trees. The ordinary barrel spray pump,, shown at Fig. 9, equipped with necessary length of hose, may be used for spraying quite extensive orchards. The use of wagon tanks holding 200 or 250 gallons of mixture often saves time when the mixture must be hauled for a long distance. Double cylinder spray pumps, as shown in Fig. 10, are most suitable for attaching to the 200 gallon wagon tanks. The various outfits and equipment necessary for preparation and application of lime and sulphur wash are described more in detail in the following paragraphs.

Fig. 4.—A convenient and economical manner of constructing Lime-Sulphur boiling plant. Suitable where steam boiling plants would be too expensive.

Fig. 5.—A crude boiling arrangement. Often used for small orchards but not recommended.

BOILING OUTFITS.

Open Kettles: As stated above, common iron kettles may be employed for preparing lime and sulphur wash for spraying a small number of trees. In certain cases where it is necessary to avoid expensive outfits the open kettle may have to be used, but ordinarily it is not the most economical method. Small iron kettles such as are often used for making lime and sulphur wash, are shown in Fig. 5. We would strongly recommend the use of a kettle of at least 25 gallons capacity, in order that enough wash may be made at one time for 50 gallons of the diluted mixture.

Kettles in a Brick Arch.—A convenient and cheap outfit for boiling lime and sulphur wash is shown in Fig. 4. This consists simply of two 60 or 80 gallon iron kettles set in a brick or stone foundation with a suitable fire box and chimney to insure getting a good draught in all kinds of weather. With an outfit of this kind large quantities of lime and sulphur wash may be made, while the first cost of the outfit will be very slight. By using 60 or 80 gallon kettles enough mixture for 100 gallons when diluted may be made at one time. In this way it is possible to prepare the mixture fast enough to keep two or three spray pumps running continuously. The greatest disadvantage of boiling in open kettles lies in the fact that the hot mixture must be dipped up in pails and poured into the spray barrel or tank. The steam boiling outfit, mentioned in the next paragraph, does away entirely with all handling of the hot mixture. Whenever the iron kettles must be used we strongly recommend construction of brick or stone foundations. Any one who has attempted to work around an unprotected kettle on a windy day, and has experienced the unpleasantness of having to dodge the fire and smoke, will thoroughly appreciate the convenience of the brick or stone arch. The saving of fuel alone is an item of considerable importance.

Steam Boiling Outfits: Wherever extensive orchards must be sprayed with lime and sulphur wash it undoubtedly pays to construct a steam boiling plant. These plants are built in many different forms but all of them correspond more or less closely with the two forms shown in Figs. 6 and 7. By using steam it is possible to boil lime and sulphur wash more quickly and thoroughly than in the open iron kettles. By the use of steam large quantities of the mixture can be made in a short time. In extensive orchards where it is necessary to run three of four spray pumps

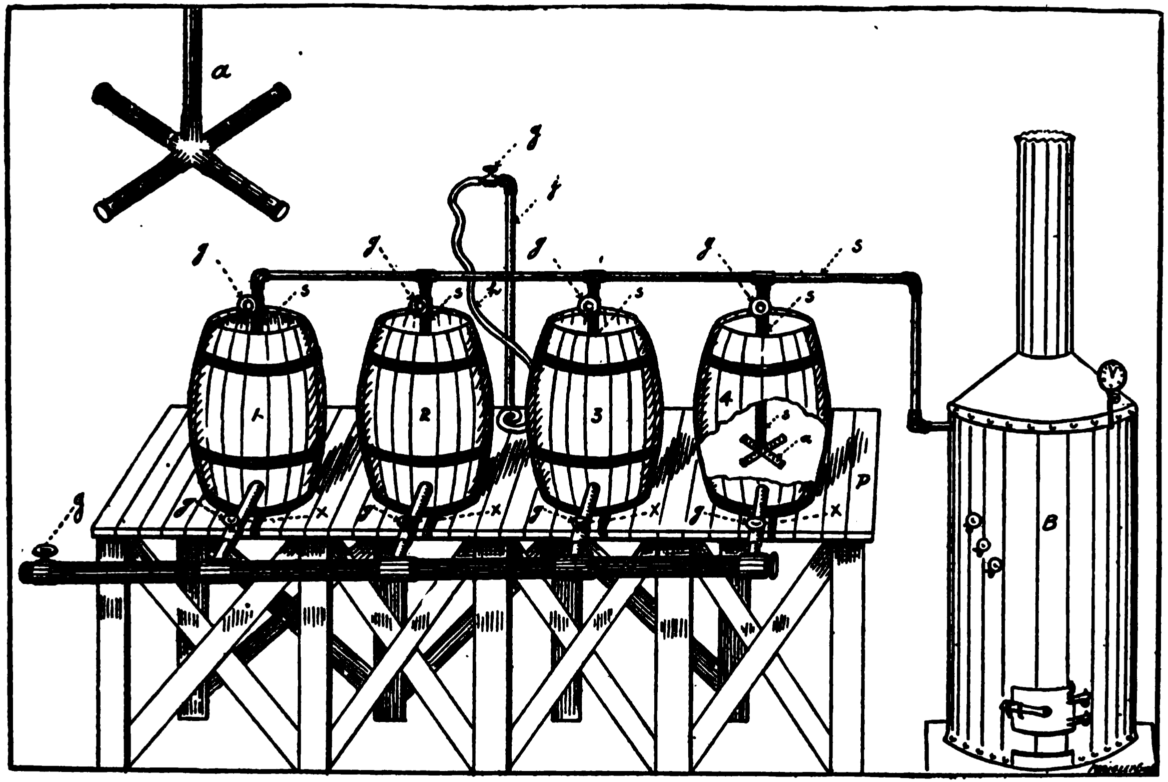

Fig. 6.—A simple steam boiling outfit for preparing lime-sulphur washes; B, boiler; ss, steam pipes; gg, gate valves; 1, 2, 3 and 4, 50-gallon barrels; xx, pipes for drawing off mixture after boiling; F, large pipe carrying liquid from pipes xx to wagon tank or spray-barrel; a, lower end of steam pipe with cross-arms and one-eighth inch openings for escape of steam; P, platform 6 feet above ground; j, pipe supplying water from elevated tank or steam jet; h, water hose for carrying clear water to 1, 2, 3 and 4.

continuously, in order to finish spraying during the winter season, it is almost necessary to arrange the plant for boiling with steam. The accompanying illustrations are intended to serve as a guide to orchardists who have to build steam boiling outfits. A glance at Figs. 6 and 7 and a comparative study of the two figures will enable almost any one to understand the plan of construction. The principal difference lies in the manner in which the steam is carried to the boiling tanks, and the way in which the water supply is arranged. Any steam boiling outfit must be constructed so as to encompass the following principles.

1st. A steam boiler of sufficient horsepower to furnish steam for cooking the mixture in all the barrels or tanks at one time.

2nd. Steam pipe connections properly fitted and arranged so as to insure convenience and economy.

3rd. The platform must be high enough to allow drawing the prepared mixture directly into the spray barrel or tank.

4th. Ample water supply must be provided.

Regarding the capacity of the boiler, it is generally estimated that one horsepower will be required for boiling mixture in one 50 gallon barrel. Where the steam boiling outfit comprises six or eight barrels a 15 horsepower boiler will give ample steam supply with sufficient surplus power for pumping water, etc. It is best to have the boiler larger than necessary as then it will not have to run to its full capacity. Portable steam boilers may be used, and also portable platform, steam pipes, etc., or the boiling plant may be situated close by boilers used for running cotton gins or other machinery.

Steam pipes for conveying steam to the barrels may be arranged by plans shown in either Fig. 6 or 7. In Fig. 6 the steam is conveyed above the line of barrels and conducted down into each barrel through a horizontal pipe, at the end of which is arranged the cross arms for distributing the steam near the bottom of the barrels. Fig. 7 shows how steam may be conveyed in a pipe running close to the bottom of the barrels and steam conveyed to each barrel by a short connection provided with a good gate-valve. We prefer the latter method of steam connection, as it requires less piping and the hot steam pipes are not in the way of the workman as they would be with the pipes running along the top of the barrels. A glance at the accompanying illustrations shows how the steam supply may be controlled so that the steam can be turned on to one barrel or any number of barrels at one time. It will be observed that each

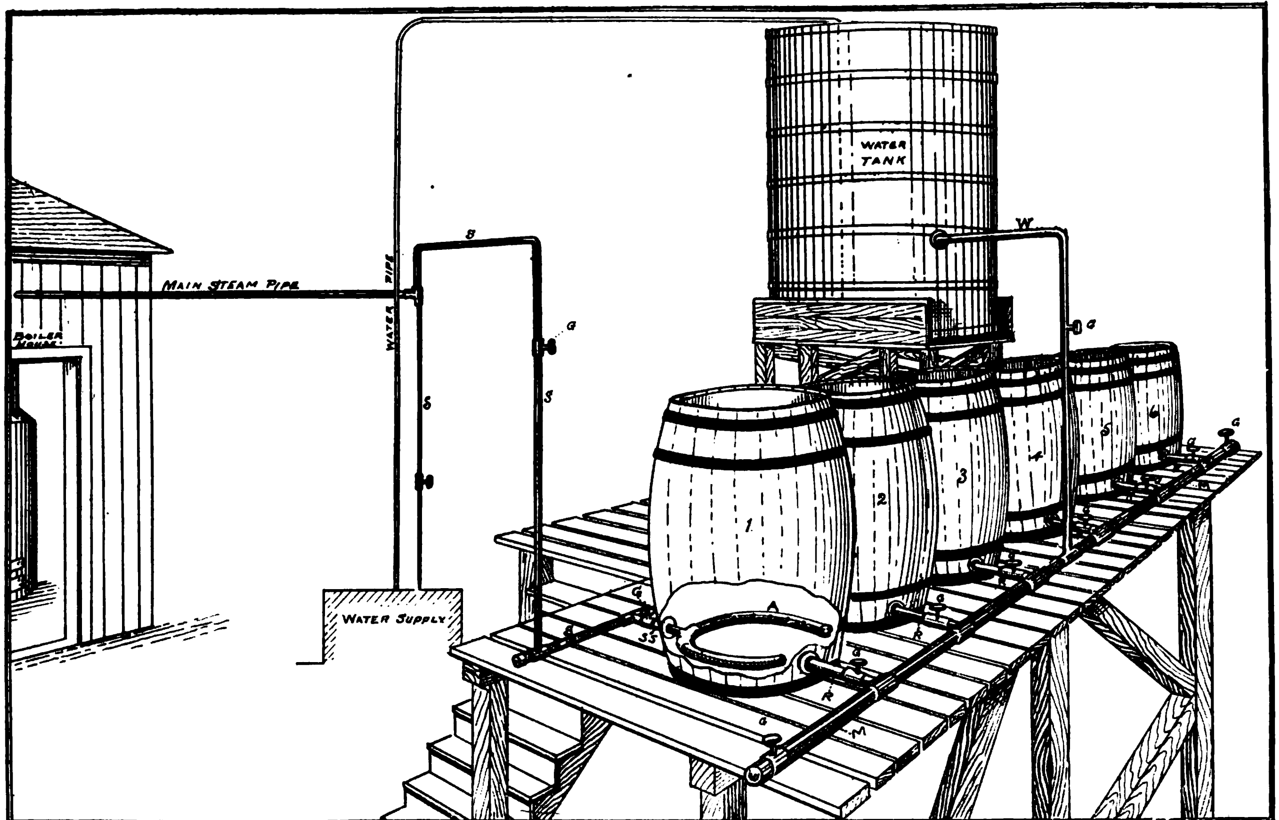

Fig. 7.—Steam boiling outfit: Showing boiler house, water tank, water supply (well or creek) platform, barrels for boiling and arrangement of steam pipes. S, steam pipes; W, water pipes; G, gate valves; R, pipes for drawing off mixture; M, main outlet pipe; ss, steam pipes leading to barrels; A, pipe for distributing steam in barrel.

pipe leading to the barrels is fitted with valve to control the steam supply. This method results in great saving of steam, for when a barrel of mixture is cooked and ready for the spray tank the steam may be turned off. When ready to draw the mixture into the spray tank, steam may be turned on for a few minutes and the mixture quickly heated to the boiling point. The best plan is to dilute the boiled mixture in the cooking barrel and turn the steam on for a few minutes before drawing out the mixture.

The platform for a steam boiling outfit should be built six or seven feet above ground, or any convenient height which will allow of drawing the prepared mixture directly into the spray barrel or tank. The height of the platform must vary to correspond with the form of spraying outfit which is used.

The water supply tank, as shown in Fig. 7 is very necessary. By having this tank elevated to give a good water pressure it is possible to fill the barrels in which the mixture is boiled simply by making use of the force of gravity. Fig. 7 illustrates how the water supply may be carried to the main outlet pipe and forced into the barrels at any time. The outlet pipe is provided with a valve at each end. When these valves are closed the water may be turned on from the tank and the valves in the pipes leading to the barrels may be opened, allowing the water to rush in, forced simply by its own weight. One barrel or all the barrels may be filled at one time. When the barrels are as full as desired the water supply may be quickly turned off. After the mixture is boiled in concentrated form it may be diluted by turning on water from the supply tank. This is the best arrangement, as it does away entirely with handling the water in pails.

SPRAYING OUTFITS.

Selection of suitable spraying outfits is a matter of great importance. The question of what kind of pump to use is one that must be determined by the individual. The decision, however, should depend mainly on the number of trees that will be sprayed. Besides the spray pump itself it is necessary to provide ample hose, extension rods, etc. As a matter of information, each part of the spraying outfit will be discussed in the following paragraphs:

Bucket Pumps: A cheap but handy spray pump for use in spraying very small orchards is shown in Fig. 8. This is what is called the bucket pump. Although not shown in the illus-

Fig. 8.—Bucket Spray Pump. Should be equipped with at least 15 foot length of hose.

Fig. 9.—Barrel Spray Pump. Notice the large Agitator, and Air Chamber.

tration, the bucket pump should be provided with at least 15 feet of hose and a 5 or 6 foot extension rod terminated by a suitable nozzle. It would scarcely pay to attempt to use a bucket pump for spraying over 75 or 100 trees.

Barrel Pumps: The most serviceable and economical outfit for spraying orchards of from 500 to 5,000 trees is the regular barrel spray pump shown in Fig. 9. These barrel pumps are usually capable of furnishing power for two leads of hose, each hose provided with a double nozzle if desirable. These barrel pumps are often fitted in wagon tanks and serve their purpose admirably. The barrel pump should be provided with a good agitator, as shown in Fig. 9, and should have an air chamber of sufficient size to insure getting a steady pressure.

Double Cylinder Spray Pumps: A pump of greater power than the barrel pump is shown in Fig. 10. This represents a strong, durable pump suitable for attaching to wagon tanks. The working part of the pump does not extend into the tank, which is an advantage on account of there being less liability of the pump becoming rusty and corroded by the mixture. As shown in the illustration, the spray mixture is drawn up to the pump through a large suction pipe. A good brass strainer is attached to the end of the suction pipe to debar any foreign matter which would clog the spray pump. We have found by experience that the double cylinder spray pump is operated almost as easily as the barrel pumps. At the same time it is possible to keep up a greater pressure. The double cylinder pumps cost more than the barrel pumps, but not enough more to debar their use. Wherever wagon tanks are used we think it advisable to use the large spray pumps, both no account of getting a greater pressure and on account of the pump being more durable.

Wagon Tanks: Wagon tanks holding 200 or 250 gallons are rapidly coming into use. Orchardists who have 10,000 or 15,000 trees to spray have found it impracticable to depend on the 50 gallon spray barrels. These 50 gallon barrels hold so little mixture that much time is lost in driving back and forth from the orchard to the place where the mixture is being made. The use of 200 or 250 gallon tanks results in much saving of both time and labor. These wagon tanks may be purchased at a cost of $18.00 or $20.00. The saving in time resulting from their use will usually more than pay for their cost the first year. Extensive orchardists who have been depending on 50 gallon

Fig. 10.—Double Cylinder Suction Spray Pump. Suitable for attaching to Wagon Spray Tanks.

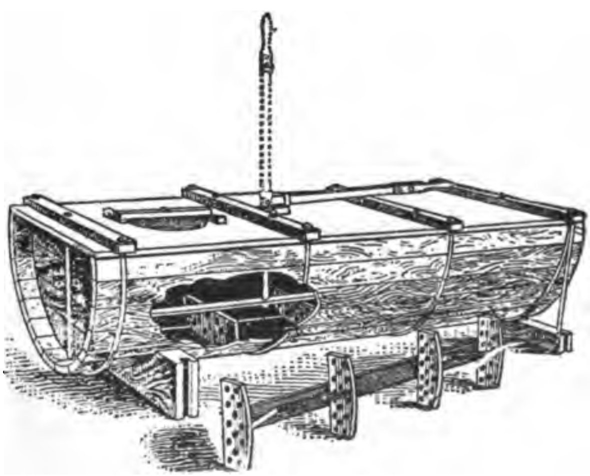

Fig. 11.—Wagon Spray Tank. This tank may be fitted to any wagon. Usually built to hold 200 to 250 gallons. The Agitator should always be secured.

barrels will undoubtedly find it to their advantage to change to the large wagon tanks.

Power Spray Pumps: Power spray pumps are now being used by many of the large orchardists, and their use is coming to be more and more universal. Fig. 12 illustrates one form of gasoline power sprayer, and Fig. 13 shows another form. We would prefer the low tank, as it would be best for driving over rough land. Compressed air power sprayers are being manufactured and used by some orchardists. In Georgia the cheap negro labor has been largely responsible for keeping orchardists from adopting the power sprayers. The illustrations shown herewith represent sprayers that have been used with great success, and we believe their adoption by orchardists in Georgia would be advisable.

Hose: The mistake is often made of attempting to use too short hose, which often results in loss of both time and material. Regardless of what kind of pump is used, whether barrel, suction, or power spray pump, it should be equipped with at least 25 foot lengths of hose. The one-half inch spray hose is most commonly used. The ordinary 4-ply, one-half inch hose can be purchased for from 10 to 12 cents a foot. A more durable, better quality hose of the same size usually costs from fourteen to sixteen cents a foot. Practice has shown that the high priced hose is cheapest in the end. A wire wound hose is now being sold by some manufacturers, and has proved to be quite serviceable. The wire wound hose is of course somewhat heavier, but it does not wear out by being dragged along the ground and will stand a great deal of abuse, such as being run over by wagons and being stepped on by mules or horses. The protection furnished by the wire also prevents the hose from kinking, and also makes the hose capable of standing a much higher pressure.

Extension Rods: No spraying outfit is complete without a good extension rod. These rods may be cut any convenient length, six or eight feet being the lengths most generally used. Bamboo covered rods are being sold by nearly all dealers, but they are no better than the rod made from one-fourth inch gas piping, which can be cut out by a blacksmith. An extension rod with stop-cock and elbowed joint is shown in Fig. 14. Fig. 15 shows more clearly how elbow is made to turn spray at right angles to the rod.

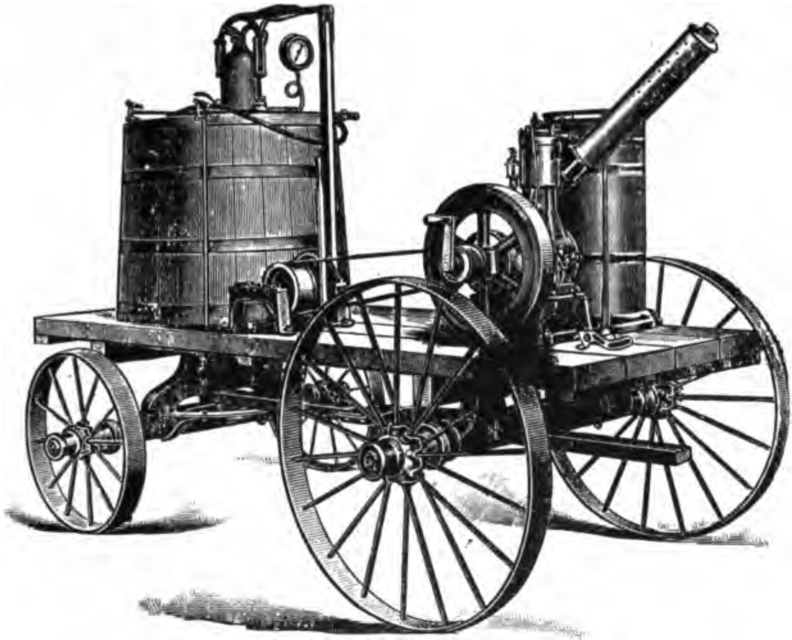

Fig. 12.—Gasoline Power Sprayer. Will easily furnish power for 4 leads of hose.

Fig. 13.—Gasoline Power Sprayer—Showing Low Spray Tank.

Stop-Cocks: These are necessary to avoid wasting material in moving from tree to tree. Whenever the nozzles become clogged the stop-cock is almost a necessity. It should always be used behind the extension rod (see Fig. 14), on the end of the hose where it is easily operated by the spray man.

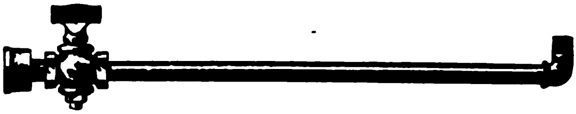

Fig. 14.—Extension rod, fitted with Stop-cock, and Elbowed Joint at extremity.

Fig. 15.—Elbow to turn spray—Vermorel Nozzle. Particularly valuable when spraying large trees.

Nozzles: The selection of nozzles is somewhat a matter of taste, but should depend largely on the form of spray pump and on the size of the trees to be sprayed. Nozzles throwing a flat spray would be valuable if they could be manufactured so as to wear without leaking. That is, without allowing the mixture to run back over the nozzle and hose while spraying is being done. Most of the nozzles throwing a flat or fan-shaped spray are undesirable on account of the fact that they soon commence to leak. In practice we have found it best to use the Vermorel type, which is shown in Fig. 16. This nozzle throws a round or cone-shaped spray. The fineness of the spray depends largely on the size of the opening in the cap of the nozzle. For spraying lime and sulphur wash the cap should be provided with a hole of about one-sixteenth inch diameter, or slightly larger, which allows the mixture to come out with considerable force. For spraying large trees it is often economical to use the double Vermorel type, shown in Fig. 17. Fig. 18 shows the Mistry nozzle which has recently come into use. The manufacturers of this nozzle claim it to be superior to the old Vermorel on account of its throwing a more mist-like spray. For lime and sulphur spraying we believe the old Vermorel type of nozzle superior to the new Mistry. Lime and sulphur wash should be applied with considerable force, hence it is not desirable to use a nozzle making a very fine spray.

Fig. 16.—Nozzle—Vermorel type.

Fig. 17. —Double Vermorel Nozzle for spraying large trees.

Strainer and Funnel: Lime-sulphur wash should always be strained before going into the spray tank. Unless well strained the mixture is liable to clog the very best spray pump, resulting in much loss of time and patience. Fig. 19 represents a combination strainer and funnel, easily made by any one. All that is required is a good substantial wooden pail, a piece of one and one-half inch iron pipe, and a wire netting to tack inside the pail. An auger hole is made in the bottom of the pail, the iron pipe screwed into this hole, and the netting tacked at a slight angle about midway of the pail. By having the netting set at an angle the mixture will run through rapidly. A strainer of this description, or one similar in design, is a very important addition to a spraying outfit.

Fig. 18.—Mistry Nozzle.

Fig. 19 —Strainer and Funnel.
(From Conn. Exp. Station Bul. No. 146.)

WHEN TO SPRAY, AND HOW OFTEN.

This is a question that has puzzled the minds of all investigators, and one that is not yet fully settled. Whether it is best to spray in fall, winter or spring, depends somewhat on circumstances. In Georgia it has been found that spring application of lime-sulphur wash is most effective, that is, spraying a few weeks before the buds open in spring. It often happens, however, that orchards are too large to be sprayed during the last few weeks before growth commences in spring, hence fall and winter applications are necessary. Orchardists must decide the question in accordance with their individual conditions. The decision should be dependent somewhat on the probable weather conditions, labor, size of orchard, extent of infestation with scale, etc.

Orchards very badly infested with San Jose scale should be sprayed twice, once in fall or early winter and again in spring before the buds open. It is well-nigh impossible to cover every portion of the tree at one spraying—though that should by all means be the aim—hence where orchards are badly infested it is advisable to spray twice each year until the scale is well in control. Thorough application of lime-sulphur wash, covering the trees from top to bottom, is necessary if good results are to be expected. Too often orchardists spray their orchards without proper regard to thoroughness, and the result is that they fail to get good results and then think the wash is responsible. Lime-sulphur wash does not spread easily like oil emulsions, and great care in spraying is necessary if good results are to be obtained. On windy days it is almost impossible to cover a tree on all sides with any mixture, and on such days the lime-sulphur wash has its advantage because it is easy to see at a glance what portion of the trees have been covered. The white colored wash will show for itself. Frequently it becomes necessary to spray one side of the trees one day and wait until the wind blows from another direction before finishing the spraying.

When spraying orchards to control the San Jose scale it is imperative that all trees be sprayed. Not simply the trees that show infestation, but every tree in the infested orchards. It is false economy to spray only the trees visibly infested. Frequently trees may be slightly infested, so slight as to be overlooked by the average orchardist. If such trees are left without spraying the scale may increase so rapidly during a single

summer that the trees will be seriously injured before the following winter.

Fall Spraying: Spraying in fall just after the leaves have about all fallen is advisable in large orchards and in orchards badly infested, where two sprayings are necessary. Orchards slightly infested may be sprayed once in fall. The reason why we do not recommend universal fall spraying is because of the fact that the mixture is usually washed off quite thoroughly by the winter rains and storms, leaving the trees unprotected in spring. In case a few scale escape the spray they may commence to breed and increase in early summer, and the young scale are not hindered from settling down as they would be where the trees are sprayed in spring, and the wash consequently adhering during the early summer months. Fall spraying in large orchards often becomes necessary on account of the difficulty of getting the work all done during late winter and spring. In such cases it would be advisable to spray the least infested portions first, leaving the worst infested portions to spray in spring. Or in case it seems possible to spray some portions of the orchard twice, spray the worst infested portion in fall, and repeat the spraying of these blocks in spring shortly before the buds open.

By fall spraying we mean spraying from the time the leaves all drop, that is, about the last of October, to the first of December.

Winter Spraying: During December and January may be considered the time of winter spraying. During these months the weather is so liable to be bad, either stormy or windy, or both, that it is difficult to do good spraying. However, in large orchards it is often necessary to spray continuously from November to the time the buds commence to open. Winter spraying is therefore often necessary, and in order to get the best results it would be advisable to spray at such times only the slight or moderately infested portions of the orchard. If a winter spraying is followed the same day by heavy rains it will often be necessary to spray the trees a second time. The second spraying should be delayed until spring, if possible, as better results may be expected at that time.

Spring Spraying: By spring spraying we mean spraying during February and up to the time the buds commence to open. In this connection it should be stated that spraying may be

continued until the blossom buds actually commence to open, and a few instances are on record where spraying while the trees were in bloom has been practiced. This is not advisable, nor would we recommend spraying later than one week before the buds first commence to show the pink color.

The advantage of spring spraying lies largely in the fact that the wash remains on the sprayed trees during the early summer months. As soon as the foliage expands the limbs are partially protected from the washing rains, which helps to make the wash adhere to the trees. Lime-sulphur wash does not kill scale immediately, as is usually the case with oil emulsions, hence it is desirable to have the wash remain on the trees for the longest time possible. It seems that the action of the lime-sulphur wash is extended over two or more months. Some nearly grown females may escape death at the first spraying; young are developed by these females; the young attempt to seek a place to settle down and if they find the limbs covered with lime-sulphur wash they are unable to find a suitable location. Even if some young scale find a portion of bark free from wash the rains and dews acting on the wash on some portion of the limbs will carry enough lime-sulphur solution to the young scale to cause their death. This may seem a far-fetched statement to some, but in no better way can we explain the undoubtedly prolonged action of the lime-sulphur wash.

PURCHASING SPRAYING EQUIPMENT.

Before purchasing spray pumps fruit growers would be wise to get catalogues from a number of spray pump companies.

For the convenience of fruit growers, and others who desire to purchase spraying machinery, we list below the names of a number of manufacturers and dealers:

Manufacturers of Spraying Machinery.

Goulds Manufacturing Co., Seneca Falls, N. Y.
The Deming Co., Salem, Ohio.
Morrill & Morley, Benton Harbor, Mich.
Field Force Pump Co., Elmira, N. Y.,
Myers Pump Co., Ashland, Ohio.
The Lenox Sprayer Co., Pittsfield, Mass.
W. H. Owen, Port Clinton, Ohio.
Wallace Machinery Co., Champaign, Ill.
Friend Manufacturing Co., Gasport, N. Y.
Hardie Spray Pump Mfg. Co., Detroit, Mich.
Wm. Stahl, Quincy, Ill.

Rochester Spray Pump Co., Rochester, N. Y.
Spraymoter Co., Buffalo, N. Y.
E. C. Brown Co., Rochester, N. Y.
Sydnor Pump & Well Co., Richmond, Va.

Georgia Dealers in Spraying Machinery and Equipment.

Beck & Gregg Hardware Co., Atlanta, Ga.
Cotton States Belting & Supply Co., Atlanta, Ga., and Savannah, Ga.
Mallary Mill Supply Co., Macon, Ga.
P. J. Berckmans Co., Augusta, Ga.

We understand that the following drug companies, and individual jobbers will handle sulphur for spraying purposes. Sulphur can be obtained from the parties named below at the lowest reasonable prices.

Georgia Dealers in Sulphur.

Jno. B. Daniel, Atlanta, Ga.
Jacobs Pharmacy, Atlanta, Ga.
Lamar & Rankin Drug Co., Atlanta, Ga.
Berckman Bros., Augusta, Ga.
J. B. Davenport Co., Augusta, Ga.
W. L. Willnet Seed Co., Augusta, Ga.
Columbia Drug Co., Savannah, Ga.
Lippman Drug Co., Savannah, Ga.
J. F. Shuptrine, Savannah, Ga.
Solomons & Co., Savannah, Ga.
Mallary Mill Supply Co., Macon, Ga.
Dr. J. B. George, Gainesville, Ga.
W. H. Harris, (Crystalline Sulphur), Fort Valley, Ga.
C. J. Hood, Commerce, Ga.
Matthews & Neely, Bainbridge, Ga.
J. A. Smith Mfg. Co., Gainesville, Ga.
Thomas Drug Co., Columbus, Ga.
Valdosta Drug Co., Valdosta, Ga.

Most of the above named wholesale drug companies deal in lime. Lime may usually be obtained from local dealers, but buyers should be careful to get the proper grade of lime.

NOTICE.

Fruit growers are urged to examine their orchards for the SAN JOSE SCALE. If any suspicious looking insects are found send specimens to the State Entomologist (Atlanta, Ga.)

By discovering the SAN JOSE SCALE before the orchards are badly infested much damage may be prevented.

The State Board of Entomology will, so far as possible, make careful investigations of all reported cases of SAN JOSE SCALE to determine the extent of the infestation.

Letters of inquiry concerning the SAN JOSE SCALE, or other insects, will be given careful attention by the State Entomologist. Letters should be accompanied by specimens whenever possible.

Address all inquiries to:

STATE ENTOMOLOGIST,

Room 5, State Capitol,

Atlanta, Ga.

GEORGIA

State Board of Entomology

BULLETIN NO. 22.—DECEMBER, 1906.

"BLACK ROOT" DISEASE
OF COTTON

This bulletin contains a report on investigations and experiments conducted in 1905–1906

BY

R. I. SMITH and A. C. LEWIS

CAPITOL BUILDING

Atlanta, Ga.

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Deputy Inspector, Adairsville.

W. W. CHASE,

Deputy Inspector, Atlanta.

ACKNOWLEDGEMENTS.

Without the generous co-operation of cotton planters the work reported on in this bulletin could not have been carried out so successfully, and we wish to thank the gentlemen named below. We feel grateful not only for the actual assistance rendered, but for the interest that the planters have shown in the investigation.

We desire to make particular mention of the following:

Prof. W. A. Orton, for furnishing seed of Jackson, U. S. No. 148 and 146 Cottons, for planting in 1905.

Hon. B. S. Miller, Columbus, Ga., for furnishing land at Zellobee on which experiments were conducted.

Mr. Ed. Howell, Vienna, Ga., for furnishing land for experimental purposes.

Sample lots of seed of Jackson and U. S. No. 148 cotton were planted at our request, and their places visited or reports received from the following: See page 265.

Mr. Joseph Burns, ... Vienna, Ga.
Mr. W. C. Chapman, ... Reynolds, Ga.
Mr. R. T. Dixon, ... Richland, Ga.
Mr. George Gilmore .... Warthen, Ga.
Mr. Z. Goss, ... Plains, Ga.
Col. W. L. Thomas, ... Plains, Ga.
Mr. E. Timmerman, ... Plains, Ga.
Mr. J. P. Wise, ... Plains, Ga.
Mr. W. H. Spann, ... Plains, Ga.
Mr. W. F. Murray, ... Plains, Ga.
Mr. T. B. Jenkins, ... Sumner, Ga.
Col. W. D. Hammack, ... Coleman, Ga.
Hon. R. T. Humber, ... Lumpkin, Ga.
Mr. W. H. Hadley, ... Chipley, Ga.
Mr. A. M. Sanders, ... Ft. Gaines, Ga.
Mr. J. B. Simons .... Buena Vista, Ga.
Mr. J. B. Wight, ... Cairo, Ga.

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"BLACK ROOT" DISEASE OF COTTON

SUMMARY AND RECOMMENDATIONS.

"Black root" disease of cotton is due to a fungus that lives in the roots and stalks of the plants, cutting off the food supply by clogging the water ducts.

The fungus lives during winter in the soil in the decaying cotton roots and stalks and probably also in the form of loose spores in the soil.

Great care should be exercised to keep the soil from infected fields from being washed by rains into other fields. Many cases have been observed where the disease was spread in this manner.

The disease is carried from one field to another on the tools used for cultivating. To avoid this danger, separate tools should be provided; or else the tools used in diseased fields should be disinfected before being taken to other fields. Corrosive sublimate, 1 part in 1,000 of water, or 4 per cent. formalin solution may be used as a disinfectant.

The cotton "black root" disease is evidently firmly established in many parts of South, and some parts of Middle Georgia. Each year the disease is spreading into new territory and becoming worse in the fields already infected.

A gradual spread of the disease must be expected unless all cotton planters use every precaution to prevent spreading the soil of diseased fields.

The disease in a field may be materially lessened if all diseased plants are dug up and burned. Where large areas of cotton are stunted the stalks should be plowed out, raked and burned, in the fall as soon as the cotton is gathered. In this way the cotton roots and stems containing the "black root" fungus may be destroyed. If allowed to remain on the land the roots and stems will rot, and the spores of the fungus will be liberated in the soil.

In fields where "black root" first appears in small areas all the diseased plants should be pulled out and burned as soon as they are discovered.

Fungicides, such as Bordeaux mixture, Copper carbonate, Sulphur, Lime-sulphur mixture, Carbolic acid, and Formalin, or applications of Lime or Kainit, to the soil, in experiments conducted by Prof. W. A. Orton, failed to control or even materially lessen the black root disease.

Experiments covering the last two seasons indicate that the disease in Georgia cannot be controlled by the use or disuse of commercial fertilizers, or by the application of large amounts of lime or tobacco dust to the soil.

Date of planting, whether early or late, does not appear to affect

the black root disease. Late planting seems even to be objectionable on account of the reduction in yield.

Variety tests of cotton have shown that certain varieties are somewhat naturally resistant to black root. Jackson Limbless seems to be the most resistant, but other varieties, such as Red Shank, and Boykin, show some resistant tendency. U. S. No. 148, is next to the Jackson in resistant qualities.

Experiments in Georgia have already shown that the resistant quality of certain varieties may be strengthened by careful selection of seed from the best plants. This may be practiced by all cotton growers.

Crossing the Jackson Limbless and native cottons has resulted in securing several resistant strains of cotton that will be tested carefully during the next two or three years.

Selection of seed from resistant plants in fields where a large per cent. of the cotton dies from the black root, is one of the best practical methods of getting resistant strains of cotton. This also may be practiced by cotton growers.

Our experiments have shown that seed from resistant plants should not be planted in one field continuously year after year without rotation of crops.

Annual selection of seed is necessary for two reasons: 1st, in order to keep the strain as pure as possible; 2nd, in order to keep from planting the seed from stunted and diseased stalks. It might even be advisable to have a seed patch isolated from other cotton.

Nematode worms, which infest the roots of common cowpeas, melons, and other crops, are a great aid to the development of black root disease. The nematodes attack the cotton roots, producing galls, and the black root fungus enters through the galls. Hence it is not advisable to grow any crop on cotton land that will tend to increase the nematodes.

Seed from resistant cotton should not be planted on land in which the nematodes are abundant, without first sowing two or three crops of nematode-resistant plants to decrease the numbers of these worms.

Rotation of crops is advisable for two distinct reasons: 1st, to reduce the black root fungus in the soil, by planting some crops on which the fungus cannot grow; 2nd, to reduce the number of nematodes in the land by planting some crop not affected by the nematode worm.

Common cowpeas are ba ly attacked by nematodes. The Iron cowpea is quite resistant to the nematodes, and also to the cowpea wilt disease. We strongly advise the substitution of Iron cowpeas for the common varieties.

Peanuts, Velvet bean and Hairy vetch are good crops for rotation to reduce the nematode worms. They also have the advantage of being gatherers of nitrogen by means of the nitrogen-fixing nodules. In all cases we have examined, the peanuts are found to have more nodules on the roots than the cowpeas on the same soil.

All investigations indicate that "black root" must be fought by combining several principles dealt with in these pages.

Our experience and the experience of investigators in other States, goes to show the value of rotation of crops and the selection of seed. This is true whether black root is present or not. Many cotton planters who do not have the black root to fight would find it to their advantage to follow many of the principles mentioned and discussed in this bulletin.

"BLACK ROOT" DISEASE OF COTTON

BY

R. I. SMITH and A. C. LEWIS

INTRODUCTION.

The cotton growers in South Georgia who have lost a portion of their cotton crop on account of the "black root" disease will hardly need an introduction to this serious drawback to successful cotton growing. The disease is not confined to South Georgia entirely, as will be seen from the map—page 248, which shows the known occurrence of the disease in Georgia. It is not uncommon for cotton growers in North Georgia to believe that their cotton is being damaged by this disease, but in the light of present knowledge we believe the "black root" is confined to the area of Georgia south of the known infested portion.

Investigation Commenced in 1904.

The Georgia State Board of Entomology first undertook the work of investigating the cause and extent of this disease in 1904. This investigation was made possible by an increased appropriation given for the support of the Board by the Legislature of 1904. The increase did not become available until January, 1905. An attempt was made, however, by Prof. Wilmon Newell, former Entomologist, to arrange to begin our investigation in the spring of 1905. In order to get selected cotton seed, which was deemed desirable for planting in 1905. Mr. Newell visited a plantation at Zellobee, Ga., owned by Hon. B. S. Miller, of Columbus, Ga. At Zellobee the black root had destroyed or nearly destroyed a number of acres of cotton that year. Seed was saved from selected plants in the diseased fields, plants which had apparently withstood the disease. (See discussion of Selecting Resistant Seed, page 267.) The seed thus selected was stored in a warehouse on Mr. Miller's plantation, and unfortunately the warehouse burned in February, 1905, rendering Mr.

Newell's work during 1904 of no avail. This explanation is given because the original intention was to get the work started favorably in 1905. After the loss of the selected seed at Zellobee, it became necessary to make other arrangements. We knew from work done by the Bureau of Plant Industry at Washington, that our best line of work lay in the direction of producing a resistant variety of cotton. We therefore wrote to Washington and secured small lots of seed of two varieties of cotton, namely: Jackson Limbless, and U. S. No. 148, which had already shown themselves to be of value for growing on land liable to develop the "black root" cotton. The sample lots of seed were all we had to commence on, except some U. S. No. 146, which has proved to be of very little value.

For land on which to conduct the investigation in 1905 we are indebted to Hon. B. S. Miller, who placed at our command an area of diseased land at Zellobee, Ga. In addition to the regular investigation carried on at Zellobee, we have been able to make investigation of diseased fields in several sections of South Georgia.

Purpose of the Investigation.

Acting in accordance with the purpose of the Legislative Act of 1904, which made it the duty of the State Entomologist to begin an investigation into the cause and injury inflicted by the "black root" disease, and to discover, if possible, some method of preventing or lessening the damage, the investigation was planned to cover several different lines of research. These may be stated as follows:

1. Distribution of the Disease in Georgia ..See page 249
2. Fertilizers as Affecting the Severity of the Disease .... " " 258
3. Date of Planting .... " " 260
4. Variety Tests to Determine Relative Resistance .... " " 261
5. Selection of Seed from Plants Resistant to "black root" .... " " 267
6. Development of Resistant Varieties by continued Selection .... " " 268

7. Crossing Varieties to increase—if possible —their Resistant Qualities .....See page 271
8. Rotation of Crops to Reduce Damage from "black root" .... " " 272
9. Distribution of Resistant Cotton Seed to Planters who could assist us in Determining their true Value... " " 275

The effect of fertilizers toward preventing "black root" was tested in 1905 at Zellobee, Ga. While the result was not encouraging, the work is reported in this bulletin. Negative results are often of value by showing the uselessness of some methods, and should prevent planters from wasting money on such experiments.

Our effort to secure resistant strains of cotton has already shown encouraging results. Cotton planters are urged to study the results recorded in this bulletin, as they are of great importance. It will be noticed by reading the following pages that the effort has been made to improve the quality of all cottons while getting strains resistant to the black root. Unless both these points are borne in mind, our endeavors might be of no value whatever. It is a well known fact that cotton yields readily to improvement by selection, and in the matter of getting cotton resistant to the black root, there is a good opportunity to improve the cotton in quality at the same time.

Georgia cotton growers will receive the full benefit of the work which has been done already, and the work that will be done in the future by the State Board of Entomology. The result of the work will be published from time to time in bulletins, as fast as our results justify such publications. While it is not possible for us to visit all sections of the State where the black root occurs, it is possible for the cotton growers, in the sections we do not visit to get the information secured through our efforts. The work at present is barely begun. There are still many things to be learned. The investigation already started will be continued as long as there is any chance of discovering any new points, or to improve on the work already done.

Distribution of seed from resistant varieties of cotton was made in 1906 to cotton planters in several different sec-

Fig. 1—Map showing known distribution of "Black root" disease of cotton in Georgia.

tions of South Georgia. This seed was grown from cotton planted at Zellobee in 1905. The object of this distribution was to test the cotton under varying conditions, both with regard to its resistance to the black root disease, and its value commercially, when grown under ordinary conditions. For 1907 we will have more seed, and thus will be able to send sample lots to more cotton planters. All who desire seed may send their names to the State Entomologist, (Atlanta, Ga.) and seed will be sent to such applicants as long as the supply lasts.

We would like to have the cotton planters feel free to send requests for information if they wish to know about any points not made sufficiently plain in this bulletin.

DISTRIBUTION.

The "black root" or "wilt" disease, as it is sometimes called, is now known to occur in the following States: North Carolina, South Carolina, Florida, Alabama, Arkansas and Georgia.

In Georgia we know that the disease occurs in the following Counties: Berrien, Bibb, Brooks, Calhoun, Chattahoochee, Colquitt, Columbia, Dooly, Dougherty, Early, Effingham, Harris, Houston, Lee, Lowndes, Macon, Marion, McDuffee, Montgomery, Muscogee, Pierce, Pulaski, Randolph, Richmond, Schley, Stewart, Sumter, Talbot, Tatnall, Terrell, Thomas, Washington, Webster, and Worth. *

There seems good reason to believe that the black root occurs also to a greater or less extent in nearly all the counties of South Georgia, and in some of the Middle Georgia counties not listed above. The accompanying map does not by any means indicate the full extent of the black root disease, but will give some indication of the distribution.

ANNUAL LOSS OCCASIONED BY BLACK ROOT.

The annual loss to Georgia cotton growers caused directly by the "black root" disease is extremely hard to estimate accurately. There is little doubt, however, but that the loss is greater than is generally supposed. For the year 1904 Hon. B. S. Miller, of Columbus, Ga., estimated the loss on his plantation at Zellobee at from $1000.00 to $1500.00. In 1905 Mr. Howell, of Vienna, Ga., placed his loss at the same amount. During the past two years we have seen many cotton fields of which from one to five acres were killed, and the remainder of the fields stunted so as

* Distribution of the "black root" was determined by personal investigations, in a majority of the counties named, and also from correspondents who sent specimens of diseased plants to be identified.

to reduce the yield about 25 to 50 per cent. There can be no doubt but that the annual loss to the cotton growers amounts to tens of thousands of dollars. The distressing feature of the disease is that it is annually becoming more severe and widespread. New fields are becoming infected each year. The very fact that cotton growers are not all aware of the seriousness of the disease and allow soil from infected fields to be carried by cultivation to un-infected fields, has helped to hasten the spread of the disease.

In view of the above facts it seems of prime importance to place reliable information in the hands of all cotton growers. A united effort on the part of the cotton planters will tend to lessen the liability of spreading the disease. Too much stress cannot be placed on the necessity of combating the black root which threatens the life of Georgia's staple crop.

HOW TO RECOGNIZE BLACK ROOT.

The name in a manner explains the nature of the black root disease. Besides the above name it is frequently called "wilt" disease, a name also somewhat suggestive. After once being recognized the "black root" is readily distinguished from other diseases to which cotton is subject in Georgia.

External Symptoms.

The first outward symptom of black root is generally a wilting of the leaves. Sometimes only one or two leaves wilt at first. The reason for this will be understood by reading the description of the growth of the fungus causing the disease. Plants first show signs of disease when they are about six weeks old. It has been found that it requires about six weeks for the fungus to develop in the plant enough to retard its growth. Many of the young plants die within a few days after the first outward symptoms of the disease appear. Badly affected plants will have many of the leaves wilted, the growth of the plant will be retarded, and before the plant really dies all the leaves will be wilted or fallen. Affected plants look very much as though they were suffering from lack of water, which is virtually the case. Frequently only a few leaves on the

plant will wilt at first and if weather conditions are favorable inducing rapid growth of the plant, the diseased plants may revive or partially recover, and again show evidence of the disease during the next dry period. Sometimes plants become badly affected and lose nearly all their leaves. Such plants may at times throw out new shoots from the stalk near the ground, and these side shoots may produce fruit. Generally, however, the fruit on the side shoots never matures as the plants die or become so weakened by the disease that they are practically worthless.

Fig. 2—Cotton plant dying from "black root" disease. From Photo by Wilmon Newell.

In the course of time plants killed by the black root lose all their leaves, and the small branches all drop off, leaving only the blackened stem standing. In walking through an affected field in September or October many of these dead cotton stalks may be seen. By counting the number of dead stalks in a single row one can easily estimate the extent of the damage. Many plants that are not killed outright by the black root are often much stunted

in growth so that they are not half as tall as the healthy plants around them. Thus we often find whole fields in which the growth of the cotton is much stunted, and the plants nearly all dead over small areas. This stunted growth is often overlooked by cotton growers, though they often complain that their cotton is not making the weed that it used to make.

As stated above, black root first appears in affected fields when the plants are about six weeks old. The disease continues its work all during the summer and plants may be gradually dying up to the time the plants are killed by frost.

INTERNAL SYMPTOMS OF BLACK ROOT.

Fig. 3—Cotton stalks cut lengthwise. On left, stem discolored by black root fungus; on right, healthy stalk. (Photo by Wilmon Newell.

With the unaided eye plants affected by black root may be distinguished by examining the roots and main stalk. The fungus causing black root, as explained in the next paragraph, develops in the woody tissue of the plant. The growth of the fungus clogs up the water ducts and when the passages become crowded with the fungus growth they turn black, or at least discolored. By cutting lengthwise of the roots or stem the woody portion of a diseased plant will appear discolored, (See Fig. 3) and the dying stalks will be quite black inside, quite different from plants that die from many other causes. This is the symptom that has given the disease the name "black root."

TRUE CAUSE OF BLACK ROOT.

It has been known beyond a doubt since 1900 that the true cause of the disease known as "black root" or "wilt" disease is a fungus,* *Neocosmospora vasinfecta* (Atk.) Erw. Sm., which attacks the roots and stems of the plants. The fungus lives in the soil, mainly in the form of spores—corresponding to the seed of higher plants—during the winter. In spring when the cotton first commences to throw out roots the fungus attacks the small rootlets. Here the fungus grows and as it increases it forces its way up into the stem, following the water ducts, and clogging them up with its mycelium.‡ The fungus in the water ducts prevents the upward flow of sap, thus cutting off the food supply. This again explains the reason why the disease first appears in the form of wilted leaves. It also explains the stunted growth which is really due to an insufficient food supply, and the dead plants killed by being entirely deprived of food.

DESCRIPTION OF THE FUNGUS.

Dr. Erwin F. Smith has worked out the life history of the black root fungus† and described its bahavior on different culture media. The junior author, Mr. Lewis, has succeeded in isolating the fungus, has grown it on different media, has made inoculations, and thus far his work agrees with that of Dr. Smith. In short, the life history of the fungus is as follows:

During the winter, while the cotton is dead, the fungus remains in the soil mainly on the decaying cotton stalks and roots. The roots of young cotton plants in spring are exposed to the fungus, which soon gains entrance to the roots. In the roots the fungus develops, producing mycelium that clogs up the water ducts. This mycelium if examined under a high power microscope looks like the drawing Fig. 4, a and d. The mycelium in the roots or stalk produce internal conidia, that is, spore bearing bodies. The spores, (Fig. 4, b and c) produced by the fungus correspond to

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*Bul. 27, U. S. Dept. of Agri., Div. Veg. Phys. & Path.

‡Mycelium is a term used by pathologists for the growing, thready part of the fungus.

†Bul. 17, U. S. Dept. of Agri., Div. Veg. Phys. & Path.

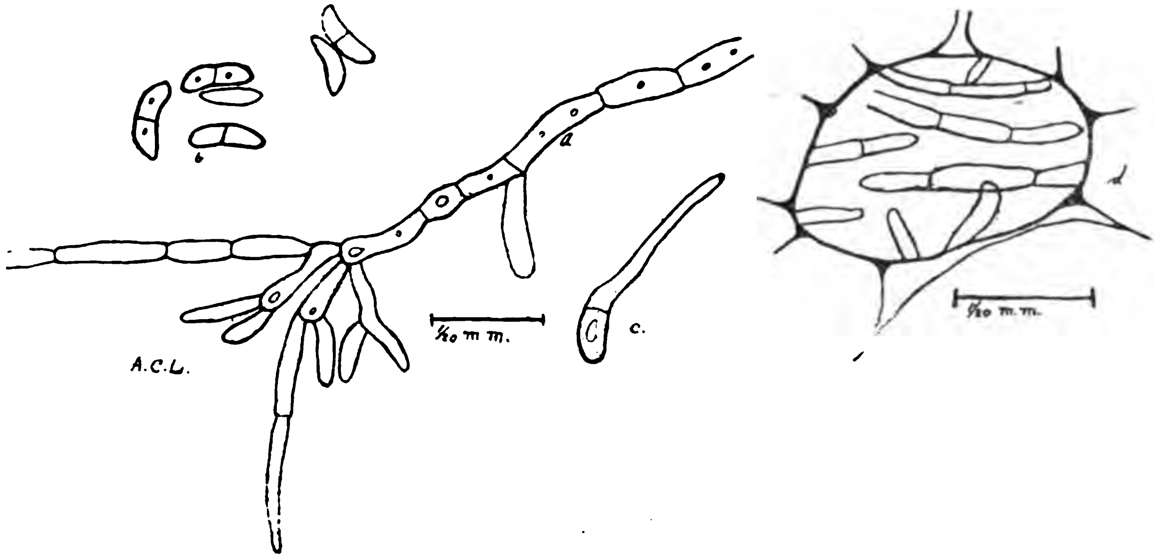

Fig. 4—Camera lucida drawings showing different stages of the "black root" fungus: a, mycelium; b, microconidia, or spores; c, one spore germinating; d, from cross section of cotton stem showing mycelium in water duct. A, b, and c, from culture on agar.

the seed of higher plants. Later on, when the stem is decayed somewhat, so that the fungus can reach the surface, external conidia are produced. The external conidia always follow the internal,, and have never been found where there was no internal mycelium. These external conidia, which are yellow, are always found in rows beneath the epidermis, or in crevices of the roots and stem of the diseased plants. Sometimes these external spores are so numerous as to give the stem a yellow color. When the bark is peeled off the yellow color, caused by the numerous spores, is discernible to the naked eye. With the aid of a one inch Coddington hand magnifying lens the spore bodies may be seen distinctly. In this manner cotton planters have sometimes been convinced that the cotton plants really have a fungus growth on the roots.

The perfect form of the fungus, the Perithecia, are found on the dead cotton stems and roots of the plants late in the fall. In this perfect form the fungus lives in the soil through the winter, together with the other two forms. In all three forms the fungus may be distributed by cultivation even during the winter season.

Relation of Nematode Worms to Black Root.

Mention will be made at various times in this Bulletin, of the presence of nematode worms, producing galls on the roots of certain plants. It has been found that the nematodes play an important part in relation to the "black root" disease.

Nematode worms are very small—almost microscopic—worms, that are present in certain soils, producing galls (See Fig. 5) on the roots of certain plants. Plants, such as common cow-peas, melons and cucumbers, are badly attacked at times. Sugar cane, okra, cabbage, collard and other field and garden crops are also attacked by nematodes. Cotton of most varieties is attacked by this gall-producing worm, and the presence of nematodes on the roots of cotton has been found to increase the tendency to black root. The reason for this is due to the fact that the fungus causing black root is obliged to force an entrance through the cotton roots, and the galls produced by nematodes offer a favorable and easy entrance for the fungus.

Fig. 5—Nematode Galls on roots of Unknown Cowpea. (From photo by A. C. Lewis.)

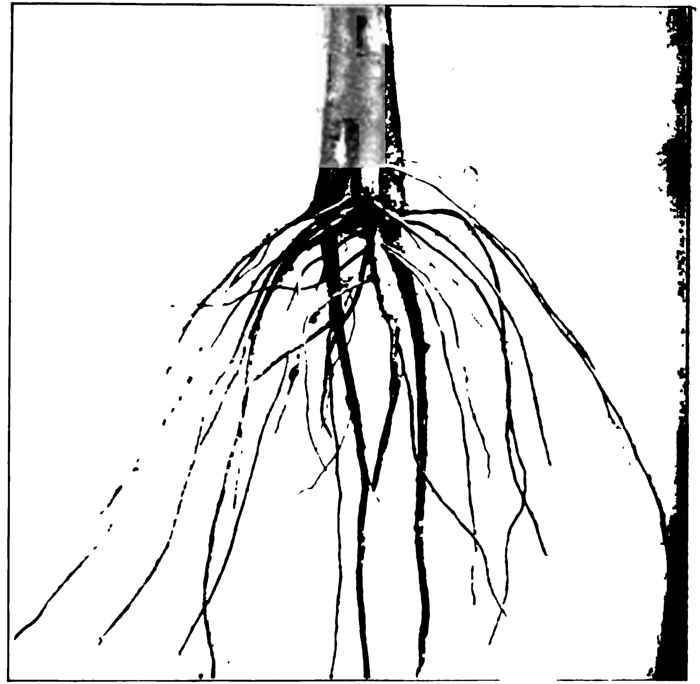

Fig. 6—Iron Cowpea. Roots are free from Nematode galls. (From photo by A. C. Lewis.)

It has been found repeatedly that cotton affected by nematodes dies worse from black root than cotton under similar conditions not attacked by the nematode worms. The connection between nematodes and black root was not at first understood. Prof. W. A. Orton called attention to this fact in his bulletin No. 17, on "Cotton Wilt Disease," mentioned elsewhere. Under rotation of crops,—page 274—will be found a list of the common plants liable to be attacked by nematodes.

The common cow-pea has often been charged with increasing the black root, that is, making it worse in land where cotton followed the cowpea. From the above statement it should be understood that the cow-pea cannot produce the black root, neither can the nematodes, but the presence of nematodes favors, and really aids, the fungus to gain entrance to the cotton roots.

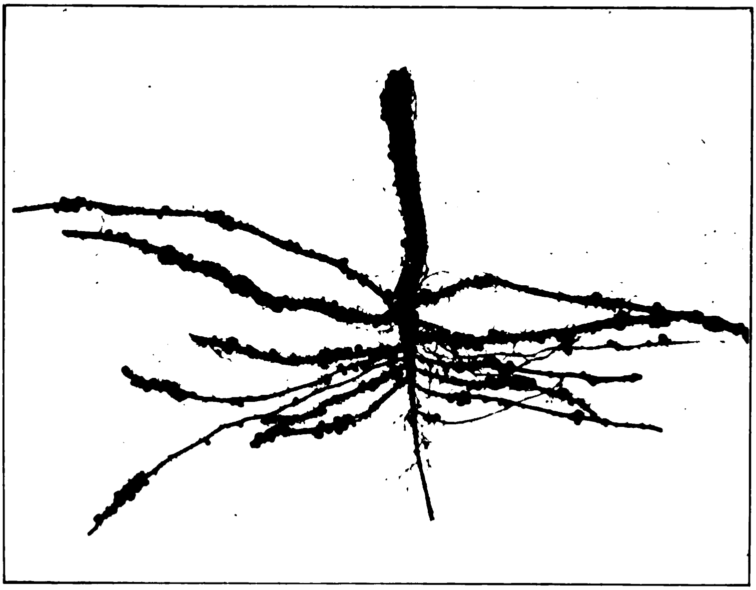

Fig. 7—Nitrogen Fixing Nodules very numerous on peanut roots. (From photo by A. C. Lewis.)

Difference Between Nematodes and Nitrogen Fixing Nodules.

The galls of the nematode worms must not be mistaken for the Nitrogen fixing nodules, that are found on the roots

of cow-peas and other Leguminous plants. The nitrogen fixing nodules appear on the sides of the roots as little round objects, as well illustrated in Fig. 7. They do not cause large knots on the roots as do the nematode worms. (See Fig. 5.)

REPORT ON EXPERIMENTS CONDUCTED DURING 1905 AND 1906.

NON-EFFECT OF FERTILIZERS.

Some cotton growers hold to the opinion that the continued and excessive use of commercial fertilizers has been responsible in a great measure for the severity of the "black root" disease of cotton. In Georgia it is a well known fact that more commercial fertilizer is used than in any other Southern State. Knowing this to be the case we deemed it advisable to make a careful test of various fertilizers to determine their relation to the black root disease. A similar test has been made by the best cotton planters in South Carolina, which went to show that fertilizers have practically no connection with the black root, but in Georgia, so far as we are aware, the test has never before been made.

The fertilizer experiment was conducted at Zellobee, Ga., on Hon. B. S. Miller's plantation.

Fertilizers of different grades and mixed in different proportions were used in the test. The aim was to use fertilizers in about the amounts usually used in Georgia. and at the same time to test fertilizers of unusual formulae as a severe test.

Check plats of cotton where no fertilizer was used were kept to compare with the fertilized plats. In this way the results obtained were rendered thoroughly reliable.

The results given in the following table show that the cotton died from the black root disease on all the plats, both the fertilized and the unfertilized. The variation in the per cent. of cotton that died on the various plats was not sufficient to indicate that the fertilizer influenced any detrimental effect, nor did it appear to be of any benefit. Of course the different fertilizers had different effects on the growth and yield of the cotton, as would be true under any

conditions. So far as having an influence on the number of plants killed by black root, we feel safe in stating that fertilizers are not to be considered.

The following table gives the grade and amount of each fertilizer used per acre, and the per cent. of cotton that died on each plat.

Fertilizers Used in Black Root Experiment.

Number pounds per acre.	Fertilizer used.	Per ct. cotton killed by black root.*
300	Acid Phosphate (16 per cent)	74
300	Muriate of Potash	82
300	Acid Phosphate (16 per cent.) and Muriate of Potash (1-2 of each)	76
400	Acid Phosphate (16 per cent) and Guano† using 1-2 of each	77
	No Fertilizer	**75**
400	Muriate of Potash and Guano† using 1-2 of each	72
300	Following mixture: Acid Phosphate (1000 lbs.) Kainit (500 lbs.) Cotton Seed Meal (500 lbs.)	73
800	Guano,† Acid Phosphate and Muriate of Potash, using 1-3 of each	74
200	Guano,† (also Tobacco dust at the rate of 800 lbs. per acre)	82
200	Guano,† (Also fresh lime at rate of 1800 lbs. per acre)	80
	No Fertilizer	**86**

A study of the above table will show that most of the plats receiving an application of fertilizer were apparently benefitted to the extent of a very small per cent., compared with the plat not fertilized, where 86 per cent. of the cotton died, but compared to the plat not fertilized, where only 75 per cent. died the benefit was hardly apparent. The average of the unfertilized plats show about 80 per cent. of the cotton killed, while the average of the plats receiving a mixed fertilizer is about 74 per cent This would indicate a benefit of 6 per cent. in favor of the unfertilized plats. Had we shown the figures representing the yield per acre we would have shown that the fertilized plats, in spite of having a slightly higher per cent. of plants killed, yielded more cotton per acre. Under present conditions in Georgia

*The per cent of cotton that died on each plot was determined by actual count as in the variety test given on page 263.

†Ready mixed fertilizer containing Phos. Acid, 10 per cent, Potash, 2 per cent, and Nitrogen 2 per cent.

the use of fertilizer is necessary. Hence the loss in yield per acre from lack of fertilizer would undoubtedly more than offset the difference in the per cent. of plants killed by black root.

Referring to the above table it will be noticed that lime was applied to one plat at the rate of 1,800 pounds per acre. This application was made because a few cotton planters have been under the impression that the soil where black root is bad, is lacking in lime.

As chemical analysis* showed that the soil was really quite deficient in lime, the experiment of applying lime to the soil was tried, but it was found to be of no value toward preventing the black root disease.

Lime as a fertilizer used on soils like the sample obtained from Zellobee, would, we think, be advisable. Lime is one of the necessary plant foods, and its addition to land deficient in lime might increase the yield of cotton to a marked extent. By increasing the yield it would indirectly be of value in connection with the control of black root, but only by way of increasing the yield in spite of the disease.

Parties who are interested in the use of lime as a fertilizer are referred to Farmers' Bulletin No. 77, of the U. S. Dept. of Agri., which may be obtained, free, by applying to the Secretary of Agriculture, Washington, D. C.

Date of Planting.

Many planters have thought that late planted cotton is less injured by black root than early planted cotton. This opinion had been quite prevalent among planters at Buena Vista, Ga., until one of their number, Mr. J. B. Simons, had a late planted field in 1904 that died very badly. Mr. Simons' experience is particularly interesting on account of the fact that he not only planted late, but planted on land that had been in other crops during 1902 and 1903. Mr. Simons' field was planted on June 3rd, 1904, following a crop of winter rye. Over 90 per cent. of his cotton died

*A chemical analysis of the soil from Zellobee, Ga., was made for us by Dr. Edgar Everhart, chemist of the Georgia Geological Survey, showing that the soil was apparently deficient in lime (CaO). Dr. Everhart found that the soil contained only .047 per cent of lime, which is a very small per cent compared to most of the soils in Georgia.

from black root. This convinced Mr. Simons and other planters around Buena Vista that no benefit could be derived from late planting.

To test the value of late planting an experiment was made at Zellobee, in 1905. One field of cotton was planted on April 18th, and another on June 5th. Both plats were of the same variety of cotton, and both received equal amounts of fertilizer and the same cultivation. Over 75 per cent. of the cotton died on both plats. The per cent. killed by black root was determined by count of the cotton plants, and not by the yield. Taking the yield into consideration, it was found that the early planted field produced over three times as much cotton as the late planted field. Hence it seems that late planting would not be profitable, even if it happened that a less number of plants died from black root.

Variety Tests of Different Cottons.

Experiment Conducted at Vienna, Ga., 1906.

From an experiment conducted in 1900 by Prof. W. A. Orton, Pathologist of the Bureau of Plant Industry, Washington, D. C., it has been demonstrated that different varieties of cotton vary greatly in susceptibility to the black root disease. In this test the Jackson proved to be the most resistant of the upland cottons.

As stated in the introduction, our first plan of investigation included the testing of Jackson cotton, which we secured from Washington. Many planters do not like the Jackson variety, which is a limbless and cluster cotton, hence our first effort was to find out if any other variety of cotton could be found that would show as much natural resistance to black root as the Jackson cotton. Seed of as many varieties as it was possible to obtain, were secured and planted under similar conditions at Vienna, Ga. The results are given in the following table. The per cent. of plants killed or badly injured by black root were determined by actual count made as follows:

Fig. 8—Variety Test, showing comparative resistance to Black Root. Two rows on left, Native Green Seed; on right Jackson cotton. (From photo by A. C. Lewis.)

A few days after the cotton had been chopped out to a stand a count was made of the number of stalks in each plat. On September 28th a count was made to determine the stalks alive at that date. Stalks nearly dead or badly stunted, enough to be of no value, were counted as dead.

Variety Test Showing Comparative Resistance to Black Root.

The figures denote the number of plants out of 1,000 that survived.

Short Staple or Upland Cottons.

Jackson, Selected seed*	815
U. S. Plant Breeding No. 148*	710
U. S. Plant Breeding No. 146*	205
Red Shank	555
Boykin	450
Baughan's Selected†	445
Rowden	410
Allen Big Boll	360
Mixed Seed from Gin	360
Storm Proof	355
Willet's Red Leaf	360
King's Improved	350
King, Early	335
Native Green Seed	275
North Georgia Seed‡	255
Excelsior	215
Peterkin	190
Russell Big Boll	100

Long Staple Cottons.

Mitafifi	880
Boyd's Prolific	440
Clarkesville	300
Ounce Boll	300
Griffin	110

From the above figures it will be seen that the Jackson and U. S. Plant Breeding No. 148 were the most resistant of the upland cottons. The U. S. No. 148 cotton originated in a selection made by Prof. W. A. Orton in Alabama, in 1901. Since that time it has proved itself able to retain the resistant quality, which helps to show the value and result of continued selection. (More will be said about selection in the following pages.)

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*Seed furnished by Bureau of Plant Industry, Wash., D. C.
†Seed furnished by E. C. Baughan, Woodbury, Ga.
‡North Ga. Seed from Adairsville to see if Ga. seed would be at all resistant.

Fig. 9—Variety Test: On left, U. S. No. 148 cotton; On right, Native Green Seed. **Shows great difference in resistance to Black Root disease. (From photo by A. C. Lewis.)**

From the results obtained from the other varieties, other than the two just mentioned, there does not appear to be much hope of securing another variety of cotton as naturally resistant to the black root as the Jackson. In all but one of the other varieties, namely, Red Shank, over 50 per cent. of the cotton died. Boykin, Baughan's Selected and Rowden showed apparently some slight resistance. Of these three varieties, however, over 50 per cent. of the plants succumbed to the black root. Counting the last three mentioned varieties, we have only five varieties of cotton which show any apparent resistance. Seed from some of the best stalks of these, and the other most promising varieties, were saved to be planted next season. From all these selections it is hoped—by further selection—to secure several strains of resistant cotton.

Of the Long Staple cottons the Mitafifi was the only one that proved to be markedly resistant, and unfortunately, this variety is not adapted to Georgia conditions. Parties in South Georgia who desire to grow the Sea Island cotton on affected land are referred to Prof. W. A. Orton, U. S. Dept. of Agri., Washington, D. C., who has secured, by selection, a very resistant strain of this cotton.

Test of Jackson and U. S. No. 148 Cotton by Individual Planters.

The Jackson and U. S. No. 148 cottons proved to be so markedly resistant to black root on our experimental plats at Zellobee, Ga., in 1905, that we decided to have them tested by planters in other parts of the State in 1906. By keeping watch of the growth and yield of these fields we hoped to find out how well the cotton resisted the disease under varying conditions. Accordingly we sent seed of the Jackson and U. S. No. 148 to cotton planters* living near the following towns:

Buena Vista, Chipley, Richland, Lumpkin, Plains, Coleman, Fort Gaines, Sumner, Cairo, and Warthen, Ga. The seed was sent to these places in March, 1906, the parties having signified their willingness to test the cotton to as-

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*For list of names see "Acknowledgements," on page 239.

sist us in our investigation, and also for their own information. With the exception of Fort Gaines, Cairo and Warthen, all the above places were visited by Mr. Lewis about the middle of September. Written reports on the growth and probable yield of the cottons were received from the places not visited. The reports from Fort Gaines and Warthen showed that both the U. S. No. 148 and the Jackson cotton were resisting the disease much better than the ordinary cotton. The seed was planted where nearly all the cotton died last season, but in spite of that fact the yield from the resistant seed was equal to the average on uninfected land. The report from Cairo was not so favorable, but we were advised that the seed was planted on rather low, wet land, badly affected by black root fungus, and also infested with the nematode worms.

Concerning the condition of the cotton from resistant seed on fields visited by Mr. Lewis, six fields of Jackson cotton were examined. Five of them were much better than the ordinary cotton, both in stand and probable yield. The other field of Jackson was on land where the black root was very bad last year. Of the six fields of U. S. No. 148 which were visited, four were found much better than the ordinary cotton. In the fields that showed the superiority of the resistant seed the plants were much taller than the ordinary cotton. The Jackson was particularly noticeable, being nearly twice as tall, and the U. S. No. 148 cotton being from 1-3 to 1-2 taller than the ordinary cotton. Of all the cotton from resistant seed, half of the fields would make a fair yield, considering the season. One field of Jackson that was found to be badly stunted was planted on land on which nearly all the cotton died last year, and the land was badly infested also with nematode worms.

It should be mentioned here that on account of unfavorable weather conditions this has been a severe season on cotton of all kinds. Shedding of squares was very noticeable in many fields, but it was observed that the Jackson did not shed more than the other varieties of cotton. One characteristic of Jackson is that it does not drop the dead squares like other cotton, and a plant may look as though it were losing a greater per cent. of squares than it really

is, compared with other cottons that drop the dead squares.

On the whole, taken year after year, we believe that the Jackson cotton will compare very favorably in yield with the other varieties commonly grown in Georgia. In 1905 at Zellobee, one acre of Jackson cotton with ordinary fertilizer, yielded 1,133 pounds of seed cotton. The Jackson has often been known to make as high as a bale to the acre. Considering the above, we believe it advisable to continue experimenting with the Jackson, but at the same time we shall endeavor to improve on this cotton by selection and crossing with other varieties.

Taken as a whole, we think the result of the variety test has given some promising results. By planting seed of naturally resistant varieties on land not too badly affected with the black root fungus, and by annual selection we may make the cotton even more resistant. The nematode worms must of course be taken into consideration, but their numbers can be reduced by planting the proper crops, as discussed under the heading, "Rotation of Crops." (See page 272.)

Selection of Seed From Resistant Plants.

Examination of a badly affected area where nearly all the cotton dies from the black root, will show that most of the remaining stalks are much stunted in size, but that a few plants are apparently thrifty and resisting the disease to a marked extent. Of two stalks in a single hill, one may die while the other may be thrifty and make a good yield of cotton. It is evident that both these plants must be exposed, to a greater or less degree, to the fungus causing the disease. Still one plant may die while the other does not succumb to the disease from some inherent cause.

In order to demonstrate what the result would be if seed selected from these resistant plants were planted on "black root" soil, a large number of selections were made in 1905 from fields in various parts of the State. Resistant plants of several varieties of cotton were selected. From one to ten plants of each variety were selected, and each stalk was given a separate number. Notes were made on the condition of each stalk and the surrounding cotton.

In explanation of the reason why several stalks of each variety of cotton were selected, and the seed from each

stalk kept separate, it may be stated that certain plants are expected to have the power of transmitting their resistant quality, while other plants may not. The results given below will show the value of several selections from each variety. Had only one or two stalks been selected, or had the seed from all selected stalks been mixed together, the average result would not have been nearly as good as the result obtained from certain individual stalks.

In the spring of 1906 the seed of the selected stalks were all planted at Vienna, Ga., on the plantation of Mr. Ed. Howell. Seed of the same variety from unselected stalks (See Variety Test, page 261) were planted side by side with the selected seed. The result of all the selections would be interesting, but only two varieties, namely, Peterkin and King's Improved, will be given in detail by way of illustration.

Result of Planting Seed From Selected Stalks.

Selection numbers represent seed from one single stalk. Per cent. figures represent plants that died from each selection.

Peterkin. Selection No.	Per cent dead	King's Improved. Selection No.	Per cent dead.
1	16	1	20
2	46	2	50
3	43	3	51
4	75	4	83
5	50	5	70
6	77	6	60
7	50		
8	87		
9	66		
10	70		

The above table illustrates the manner in which the relative resistance of each selection was determined. Below is given a list of all varieties from which selections were made. The number of selections from each variety and the number of plants from each selection that transmitted the resisting quality to their progeny is given below.

Fig. 10—Result of Planting Seed From Selected Stalks: On left, one row from selected stalk of Excelsior; On right, two rows from unselected seed of Excelsior. Photograph taken Oct. 12th, 1906, Vienna, Ga., (By A. C. Lewis.)

Fig. 11—Result of Selecting Stalks of Different Varieties, Showing Comparative Resistance: On left, two rows Native Green Seed; On right, two rows North Georgia Seed. (Seed from selected stalks.) Photograph taken Oct. 18th, Zellobee, Ga., (By A. C. Lewis.)

List of Varieties and Selections From Each.

Variety	No. of plants selected	No. of selections showing resistance
Jackson	11	All (11) quite resistant.
U. S. No. 148	7	All (7) " "
U. S. No. 146	7	None showed resistance.
No. Georgia Gin Seed	9	Two showed resistance.
Native Green Seed	7	" " "
Russell Big Boll	10	Two (somewhat resistant.)
KiKoKi	6	One showed resistance.
King's Improved	6	" " "
Peterkin	10	" " "
Excelsior	1	" " "
Unknown Variety	3	" " "
Total No.	77	29

The above totals include the Jackson and U. S. No. 148, of which all selections showed resistance. In order to draw a fair conclusion concerning the average result from the above we will leave out the first two varieties and consider only the remainder. We then have the following:

Out of 59 selections from 9 varieties of cotton, 11 transmitted the resistant quality to their progeny. In the preceding table showing the comparison of selections of Peterkin and King's Improved, it will be noticed that the seed from the best stalk produced plants of which not more than 16 per cent. died. Of the 11 selections just mentioned, the per cent. of plants dying from black root was not greater than 20 per cent. in any case.

As an illustration of the manner in which certain selections transmitted the resistant quality to their progeny, let us notice the Peterkin variety. Out of ten selections only one transmitted the resistant quality to any marked extent. The other nine selections of this variety died to the extent of 43 to 87 per cent. Selections from the Native Green Seed gave much better results. Of this variety out of only 7 selections, two transmitted the resistant quality to a marked extent. From 5 selections of the KiKoKi one transmitted the resistant quality to its progeny, and from 6 selections of the King's Improved, one showed marked resistance. The result with Excelsior was unusual, as the single selection transmitted the resistant quality, while in the Variety Test this cotton is near the bottom of the list. However, it all helps to show what selection may accomplish.

Value of Continued Selection.

From the above it will be seen that we have the beginning of a resistant strain of cotton for each of the varieties selected. By continued selection each year we aim to make these strains of cotton still more resistant, and especially to fix the resistant quality for each strain or variety of cotton. Some selections will undoubtedly have to be discarded, when further tests show them to be of little or no value. This must be expected. Still, in view of results already secured in Georgia, and the experiments conducted by Prof. W. A. Orton, in South Carolina, there seems good reason to believe that our efforts may be rewarded by securing one or more resistant strains of cotton, by following the method described above.

The investigation has shown the importance of saving the seed from each plant separately, and selecting a large number of plants when beginning the experiment. After the first year it is only necessary to save the seed from a few of the best stalks for planting the following season. For example, out of our 10 Peterkin selections, seed will be saved only from the best plants derived from Selection No. 1. The dead and stunted plants should be pulled up and discarded in order to assure gathering seed only from strong, healthy plants.

Hybridizing Experiments. (Crossing Varieties.)

In order to determine if it would be possible to increase the resistance of ordinary cottons, to the black root disease, by crossing them with Jackson cotton, a number of crosses were made last year. The best, most resistant and most hardy plants of several standard varieties were selected for making the crosses. The pollen from the blooms of these plants was carefully transferred, by hand to Jackson blooms that had been properly prepared for the purpose. The prepared blooms were covered with small paper sacks to protect them from foreign pollen. This work requires much care. Full directions concerning the method employed will be furnished any one who desires to take up this feature of the work.

It is yet too early to tell what results will be obtained from this work. All that can be stated at present is that

during 1906, the hybrids obtained by crossing varieties in 1905, were very hardy, and in most cases resisted the disease to a considerable extent. Many of the hybrids fruited well, some being the best fruited of any cotton on the experimental plats at Zellobee. A detailed report will be made on the result of the hybridizing experiment when the work has been followed long enough to furnish valuable results.

Rotation of Crops.

Owing to the fact that black root fungus grows only on cotton and okra—of the crops commonly grown in Georgia—it would seem that if affected fields were planted in other crops for a few years the severity of the disease might be greatly reduced. Thus far all attempts have failed to completely eradicate the black root fungus from the soil of infected fields. Experiments conducted by Prof. W. A Orton,* have shown that the fungus may still be present in soil after four years' rest from cotton. In fact, it seems doubtful if the fungus can ever be gotten out of the soil entirely. Hence we must learn how to control the disease so that a crop of cotton may be made on infected soil.

Rotation of crops seems to offer some measure of relief even if the land cannot be entirely freed from the black root fungus. Our observations during 1905-06, showed that even one year in corn and Iron cowpea greatly reduced the severity of the disease in the crop following.

The benefit from a one-year rotation was very marked in our experiments at Zellobee. This was determined by planting two plats in other crops. The first plat was planted in sorghum, and the second in corn and iron cowpea. This planting was in 1905. In 1906 both plats were planted in cotton of the Jackson, U. S. No. 148, and Native Green Seed varieties. The result was that only about 50 per cent. of the Native Green Seed died, and only 10 per cent. of the Jackson and U. S. No. 148. On this land the year before the sorghum and corn were planted, Native Green Seed cotton died almost completely. The Jackson and U. S. No. 148 had died also to a greater extent before the ro-

*Bul. No. 27, U. S. Dept. of Agri., Div. Veg. Phys. & Path.

tation. Another illustration similar to the above is given farther on.

Sorghum has been considered by some cotton planters as a plant that is good to help kill out the black root fungus in infected soil. It is also considered to be a crop that is hard on the land. In the above experiment it was found that sorghum is about as good as corn and Iron cowpea as a rotation crop, but that it is no better. Cotton died to about the same extent on the plat following sorghum as on the plat following corn and Iron cowpea. Hence if the sorghum is too hard on the land, it would be advisable to discontinue its planting.

The Iron cowpea has been used in our experiments because of the fact that it has proved to be naturally resistant to the nematode worm, and quite resistant to the "wilt" disease of the cowpeas. Observations made at Zellobee and other points all indicate that the above statement is true.

In 1905 Col. W. D. Hammack, of Coleman, Ga., had a field that well illustrated the danger of planting the common cowpea. This field was visited by Mr. Lewis in the fall of 1905. The field had been planted the season before in corn and cowpeas, the cowpeas being planted every third row. In August it was easy to be seen that the black root had killed a much larger per cent. of cotton in every third row than in the other rows. Over 75 per cent. of the cotton was dead in the row that had been in cowpeas, while only 25 to 50 per cent. of the cotton was dead in the other rows. Col. Hammack reported later that the plants were almost entirely gone from the cowpea rows by the time the cotton was ready to pick.

Sugar cane has proved to be another crop that indirectly increases the black root. During the past two seasons many fields have been seen that prove this to be true. Many cotton growers seem to be well aware of the fact that black root is worse in cotton following sugar cane. Why this is true they have not been able to say, but examination has shown that the roots of sugar cane are badly infested with the nematode worms. All experiments and observations indicate that we must avoid planting crops readily infested with nematodes.

During the two years over which the investigation by the writers has been carried on, it has been impossible to demonstrate the effect, or non-effect, of more than one year rotation. However, as an illustration of the way black root increases when cotton is planted year after year, the following is of interest:

At Zellobee a field of Native Green Seed cotton in 1904 died very badly. The field was planted again in 1905 in Native Green Seed, Jackson and U. S. No. 148. As would be expected, the Native Green Seed died almost completely, but the Jackson and U. S. No. 148 (resistant seed) died only about 15 to 20 per cent. The field was again planted in 1906 with the same cottons, with the result that the Native Green Seed died completely, and the Jackson and U. S. No. 148 died about 20 to 25 per cent., and many more stalks were stunted than there were the year previous. This result of three years' planting with the Native Green Seed shows how useless it is to continue planting, year after year, seed of the ordinary cotton. And it also shows that even the resistant cottons will die more when planted year after year on the same field. This is an imporant point. When endeavoring to get a resistant seed, care must be taken not to plant the selected seed on the worst infected land for two consecutive years.

In a successful crop rotation, for the purpose of lessening the black root disease, we must not plant any crop that will directly increase the fungus (the important one in Georgia is okra), nor any plant that will tend to increase the number of nematodes in the soil. Frequent examinations of the roots of the Iron cowpea have shown that they are practically free from nematodes, even when the common cowpea in connecting fields are found badly infested. For the basis of a system of crop rotation we would therefore strongly advise the adoption of the Iron cowpea. Among the common crops grown in South Georgia the following are frequently badly infested by the nematodes, namely: Cowpeas, (all the common varieties) Okra, Cabbage, Collard, Watermelon, Potato, Tomato, Sunflower, Gourd, and Peach trees. In addition to the above, Prof. Atkinson* mentions the following plants as being badly

*Ala. Exp. Station, Bul. No. 9, new series, 1899.

affected in Alabama: Citron, bird's foot clover (*Lotus corniculatus*) rutabaga, parsnip, and salsify.

Distribution of Resistant Cotton Seed.

As already mentioned in the Introduction and the discussion of Variety Tests on page 261, sample lots of seed of certain varieties of cotton have been sent to cotton planters in various parts of Georgia. Concerning this distribution we desire to say a few words, more particularly with regard to the purpose of the distribution.

It has been shown by our experiments in Georgia, which agree in most respects with investigation carried on a few years ago by the Bureau of Plant Industry, in So. Carolina, that the most prominent feature of black root control lies in securing varieties or strains of resistant cotton. This we have endeavored to do both in the variety test, mentioned on page 261, and in the selection of seed from apparently resistant plants—page 267. Each year it will be possible to improve on the strains of cotton that we already have, but in order to demonstrate the value of the new strains of cotton the seed must be tested under all conditions. The only way to learn the true value of the new strains of cotton is to have the seed planted by individual cotton planters who will report the growth and yield of the cotton. As mentioned elsewhere in this bulletin, a number of planters in 1906 were sent sample lots of seed of Jackson and U. S. No. 148, two cottons that have already shown marked resistance to the black root. After the next season we hope to have several other strains of cotton that are worthy of being tested by individual planters. Of course in this work of distribution, on account of the short supply of seed, it will not be possible to send seed to all who apply, but the intention will be to send seed to as many localities as possible, in order to encounter different conditions of soil, cultivation, etc.

A further discussion of this phase of the subject seems unnecessary, as the situation must be apparent to those who have taken time to read this bulletin.